-

A Summary of Current Program and
Preliminary Report of Progress

OILSEEDS AND PEANUT RESEARCH

of the

United States Department of Agriculture
and related work of the
State Agricultural Experiment Stations

This progress report is primarily a research tool for use of scientists and administrators in program coordination, development, and evaluation; and for use of advisory committees in program review and development of recommendations for future research programs.

The summaries of research progress include some tentative results that have not been tested sufficiently to justify general release. Such findings, when adequately confirmed, will be released promptly through established channels. Because of this, the report is not intended for publication and should not be referred to in literature citations. Copies are distributed only to members of Department staff, advisory committee members, and others having a special interest in the development of public agricultural research programs.

This report also includes a list of publications reporting results of U.S.D.A. and cooperative research issued during the past year. Current agricultural research findings are also published in the monthly U.S.D.A. publications, Agricultural Research and The Farm Index.

UNITED STATES DEPARTMENT OF AGRICULTURE
Washington, D. C. 20250

December 1, 1966

RESEARCH ADVISORY COMMITTEES

The following Research Advisory Committees were established pursuant to Title III of the Research and Marketing Act of 1946:

1. Farm Resources and Facilities
2. Utilization
3. Human Nutrition & Consumer Use
4. Marketing
5. Agricultural Economics
6. Forestry
7. Animal & Animal Products
8. Cotton
9. Grain and Forage Crops
10. Horticultural Crops
11. Oilseed, Peanut & Sugar Crops
12. Plant Science & Entomology
13. Tobacco

The source materials used by the advisory committees include organizational unit progress reports and subject matter progress reports. The latter contain information which was first reported in the organizational reports and has been assembled for use by commodity committees. The number prefixes shown below refer to advisory committees listed above.

ORGANIZATIONAL UNIT PROGRESS REPORTS

Agricultural Research Service (ARS)

1 - Agricultural Engineering
1 - Soil & Water Conservation
2 - Utilization -- Eastern
2 - Utilization -- Northern
2 - Utilization -- Southern
2 - Utilization -- Western
3 - Human Nutrition
3 - Consumer & Food Economics
4 - Market Quality
4 - Transportation & Facilities
7 - Animal Husbandry
7 - Animal Disease & Parasite
12 - Crops
12 - Entomology

Economic Research Service (ERS)

1, 5 - Economic Development
4, 5 - Marketing Economics
5 - Farm Production Economics
5 - Economic & Statistical Analysis
5 - Foreign Development & Trade
5 - Foreign Regional Analysis
5 - Natural Resource Economics

6 - Forest Rervice - Research (FS)

4, 5 - Farmer Cooperative Service (FCS)

4, 5 - Statistical Reporting Service (SRS)

SUBJECT MATTER PROGRESS REPORTS

6 - Forestry (other than Forest Service)
7 - Animal-Poultry & Products Research other than Husbandry, Disease and Parasite
8 - Cotton and Cottonseed
9 - Grain and Forage Crops
10 - Horticultural Crops
11 - Oilseed and Peanut
12 - Sugar
13 - Tobacco

A copy of any of the reports may be requested from Max Hinds, Executive Secretary, Oilseed, Peanut and Sugar Crops Research Advisory Committee, Research Program Development & Evaluation Staff, U. S. Department of Agriculture, Washington, D. C. 20250.

TABLE OF CONTENTS

INTRODUCTION

This report deals with research directly related to the production, processing, distribution, and consumption of oilseeds and peanuts, and oilseed and peanut products. It does not include extensive cross commodity work, much of which is basic in character, which contributes to the solution of not only oilseed and peanut problems, but also to the problems of other commodities. Progress on cross commodity work is found in the organization unit reports of the several divisions.

The report is presented under three main headings: Farm Research; Nutrition, Consumer, and Industrial Use Research; and Marketing and Economic Research. There is also a breakdown by problem areas as shown in the table of contents. For each subject matter area, there is a statement of the problem, USDA and cooperative program, information about the program at the State Experiment Station, if available, a summary of progress during the past year on USDA and cooperative programs and a list of publications including State work where this information is available.

Oilseed and peanut research is supported by (1) Federal funds appropriated to the research agencies of the U. S. Department of Agriculture, (2) Federal and State funds appropriated to the State Agricultural Experiment Stations, and (3) private funds allotted, largely by oilseed and peanut industries, to research carried on in private laboratories or to support of State Station or USDA work.

Research by USDA

Farm Research in the Agricultural Research Service dealing with oilseeds and peanuts comprises investigations on breeding and genetics, variety evaluation, culture, diseases, nematodes, weed control, insects, and crop harvesting and handling operations and equipment. This research is conducted by the Crops, Entomology, and Agricultural Engineering Divisions. The work involves 109 professional man-years of scientific effort.

Nutrition, Consumer and Industrial Use Research in the Agricultural Research Service pertains to improved methods and equipment for mill processing of oilseeds and peanuts; development of new and improved food, feed, industrial uses of oilseed and peanut products; and nutrient values of oilseeds and peanuts. It is carried out by the Eastern, Northern, Southern, and Western Utilization Research and Development Divisions; Consumer and Food Economics Research Division; and Human Nutrition Research Division. The work in these divisions involves 104 professional man-years of scientific effort.

Marketing and Economic Research is done din three services. Marketing research in the Agricultural Research Service dealing with oilseeds and peanuts is concerned primarily with the physical and biological aspects

of assembly, packaging, transporting, storing and distribution from the time the product leaves the farm until it reaches the ultimate consumer. It is carried out by the Market Quality, and Transportation and Facilities Research Divisions. The oilseed and peanut research in these divisions involves 11 professional man-years of scientific effort. Economic research conducted in the Economic Research Service deals with marketing costs, margins, and efficiency; market potentials; market structure, practices, and competition; outlook and situation; and supply, demand, and price. Research in cooperative marketing is conducted by the Farmers Cooperative Service. The oilseed and peanut research in these services involves 8 professional man-years of scientific effort.

Interrelationships among Department, State, and Private Research

A large part of the Department's research is cooperative with State Experiment Stations. Many Department employees are located at State Stations and use laboratory and office space close to or furnished by the station. Cooperative work is jointly planned, frequently with the representatives of the producers or industry affected participating. The nature of cooperation varies with each study. It is developed so as to fully utilize the personnel and other resources of the cooperators, which frequently includes resources contributed by the interested producers or industry.

Including both cooperative and State Station projects, oilseed and peanut research is in progress in about half of the 53 State Agricultural Experiment Stations. The type of work to which the largest amount of effort is devoted includes breeding and genetics, culture, diseases, variety evaluation, insect control, weed control, agricultural engineering, utilization, and economics. There is regular exchange of information between Station and Department scientists to assure that the programs complement each other and to eliminate unnecessary duplication.

Industry's participation in oilseed and peanut research is carried out primarily by manufacturers of farm machinery and equipment, processors of intermediate products, such as refined vegetable oil, and by manufacturers of consumer products, such as shortening, amrgarine, and peanut butter.

Basic research done by the Department and States is utilized by industrial research laboratories in further development of improved products and equipment. Industry's cooperation in supporting oilseed and peanut research at Federal and State Stations has contributed greatly to its success.

Examples of Recent Research Accomplishments by USDA and Cooperating Scientists

Soy flour process for local production in developing countries. A favored approach for alleviating the food shortages in the developing nations is to provide low-cost protein foods based on crops that can be grown locally. For this purpose, Department engineers have devised a simple method for hand production of full-fat soy flour. The process is designed for use in foreign villages where skilled labor, electric power, and steam are not available.

In this process, both equipment and fuel requirements are minimal and hand labor is used in place of mechanical power. The total cost of equipment is estimated to be below $200 for producing about 300 pounds of full-fat soy flour per 8-hour day. This production, which can be accomplished by five men, is sufficient to supply 35 grams of protein per day (1/2 the minimum daily protein requirement) to more than 1,600 adults. The remaining step to be taken is on-site demonstration of this simple flour process under the environmental conditions of a specified developing country.

Linseed oil protection for concrete. Use of salt for ice and snow removal has caused increasing damage to concrete highways under winter conditions. Department scientists cooperating with industrial, Federal, State, and local groups have demonstrated that thin coatings of linseed oil help protect concrete against scaling and spalling. The oil may be applied as a solution of oil-mineral spirits or as a Department-developed oil-water emulsion. Application by spraying is usually most economical, but alternate methods may be used.

Concrete varies so much in composition and performance, and roads are subject to such different uses that obtaining conclusive technical information requires long periods of time. However, results already have been positive enough that the State of Illinois recently specified the use of linseed oil on all new concrete roads instead of only on bridges as previously required. Country-wide adoption would result in greatly increased consumption of linseed oil. Flaxseed from which linseed oil is obtained is an important crop in the States of Minnesota, North Dakota, South Dakota, and Texas.

Partially Defatted Peanuts Now Produced Commercially. Industry sources have been quoted as expecting partially defatted peanuts to set off "the biggest advance in peanut consumption since man cracked open his first peanut shell." Each partially defatted peanut, prepared by mechanical pressing and without the use of solvents, contains up to 57% fewer calories than does a conventionally roasted peanut. One major company reports successful distribution of the product in small flexible bags and soon plans to introduce larger packages. Another company is producing and selling pressed peanuts for use in the new product. Still another is conducting market tests to decide whether or not it should go into full-scale production and distribution. Several other firms have shown interest in the product. In addition to its consumer appeal as a delicious snack, the new product may be useful as an ingredient in other processed and convenience foods and also appears to have potential as a rich source of protein.

High-Protein Food from Safflower Meal. Safflower meal is a rich source of vegetable protein, but cannot be used directly as a food. The fiber content is three times the acceptable level, and the meal contains a bitter flavor which is not destroyed by cooking. The Department has now developed processes that overcome both problems. Safflower seeds are partially decorticated by screening and air classification, the oil is removed by pressing and solvent extraction, then more fiber is removed by dry milling of the oil-free meal. The resulting product is about 60% protein and 3 to 5% fiber. At this stage it is immediately useful as a superior animal feed ingredient. If the bitter flavor is then removed by extracting with alcohol or acetone, the protein content is increased to about 75% and the flavor becomes desirably bland. Preliminary results indicate that this high-protein safflower meal can be incorporated in bread or in meat-substitute dishes to make nutritious, palatable foods. The critical shortage of protein foods in many parts of the world underscores the importance of these findings.

Superior Cooking Oil from New Variety of Safflower. Department scientists, working in cooperation with plant breeders at the California Agricultural Experiment Station, have shown that a new variety of safflower with high content of oleic acid provides an oil that is comparable in quality with the best hydrogenated oils presently used in deep fat frying. High-oleic safflower oil is stable to air oxidation without being hydrogenated and remains fluid at refrigerator temperatures. Thus processing and handling costs are low. Many large commercial suppliers and users of edible oil in this country have requested samples of the new oil and detailed information on this work. The potential use is enormous--one of these users alone consumes 100 million pounds of frying oil each year.

Economical Method for Producing Industrial Chemical Opens New Markets for Castor. Highly efficient methods have been developed for converting low-cost hydrogenated castor oil esters to ketostearate esters, which have unique physical and chemical properties that should make them industrially valuable. Several companies are evaluating the ketostearates for such uses as permanent-type automotive lubricants and mold-release compounds. The latter are mixed with polyethylene so that molded products such as phonograph records are released quickly and easily from the mold without sticking. Inexpensive catalysts rapidly and completely convert castor esters to ketostearates. Processing costs are only a few cents a pound. One industry spokesman foresees an immediate yearly market for several million pounds of ketostearates in lubricant applications. Another large producer has embarked on an extensive exploratory research program to develop uses for ketostearates, now that they can be prepared by this low-cost method.

Examples of Recent Accomplishments of the State Agricultural Experiment Stations

Commercial Peanut Butter Ice Cream Developed. Research sponsored jointly by the Georgia Agricultural Experiment Station and the Georgia Agricultural Commodity Commission for Peanuts has resulted in the development of a formula and process for commercial peanut butter ice cream. Two commercial ice cream firms in Georgia cooperated in the development. Several firms outside the State evaluated it. Difficulties of moisture absorption and poor texture were overcome by very fine grinding and use of suitable stabilizers.

I. FARM RESEARCH

SOYBEAN BREEDING AND GENETICS, DISEASES, CULTURE, QUALITY, AND PHYSIOLOGY
Crops Research Division, ARS

Problem. Soybean research is directed toward obtaining higher average production. Seed yields have not increased in recent years as rapidly as domestic and foreign requirements. Available land for further acreage increases is limited. Since the adaptability of soybean varieties is critically affected by the relative length of days and nights, and by soil, climate, and disease conditions, it is necessary to produce varieties adapted to many environmental conditions.

Much of the increased yield in nonlegumes in recent years can be attributed to nitrogen fertilization. The soybean, as a legume, has an endogenous source of nitrogen in the symbiotic nodule system. However, there are many genetic strains of the nodulating bacteria, and they differ in compatibility with different soybean genotypes, in adaptability to soil conditions, and probably in the effectiveness with which they are able to fix atmospheric nitrogen in the symbiotic relationship. More detailed and precise information about bacteria-nitrogen-soybean interactions is one of the most pressing needs in the research program, and is receiving attention from several aspects.

Soybeans are important commercially because of their high content of oil and protein. Historically, the levels of these two important constituents have been negatively correlated, and protein negatively correlated with seed yield. It is difficult, therefore, to combine breeding programs seeking to improve yield, oil, and protein. This dilution of research effort to cover several objectives reduces progress toward any one objective. In addition, soybean diseases in recent years have increased in serious proportion so that certain diseases may approach catastrophic levels for some farmers. Genetic resistance has proved an effective method of dealing with certain diseases. However, the search for resistance requires screening many thousands of genotypes in the seed collection and is time-consuming. Once resistance has been found, incorporation into good agronomic types may be simple or complex depending on the number of genetic factors and the genetic linkages which exist; and the ease with which resistance can be identified. Adequate resistance has not been found for some of the most important diseases.

Increased yield in many crop species has been obtained by hybridization. Cross-pollination by hand in soybeans is very tedious and no male sterility has been discovered. Techniques to increase natural crossing and new efficient methods for handling segregating material are needed. Some research is being directed in this area.

USDA AND COOPERATIVE PROGRAM

The Department has a continuing program involving breeders, geneticists, plant pathologists, physiologists, and chemists engaged in both basic studies and the application of known principles to the solution of growers' problems. Research is conducted at Beltsville, Maryland, and in cooperation with Agricultural Experiment Stations of California, Florida, Illinois, Indiana, Iowa, Maryland, Mississippi, Missouri, and North Carolina. In addition, the evaluation of experimental selections is conducted in formal cooperation with the Experiment Stations of Alabama, Arkansas, Georgia, Kansas, Kentucky, Louisiana, Michigan, Minnesota, Nebraska, North Dakota, Ohio, Oklahoma, South Carolina, South Dakota, Tennessee, Texas, Virginia, and other soybean producing States. Cooperative agreements, contracts, and grants for research in mycotoxins (Iowa and Illinois Agricultural Experiment Stations), root growth (Indiana and Illinois Agricultural Experiment Stations), biochemical nature of nematode resistance (Boyce Thompson Institute for Plant Research), resistance to soybean cyst nematode (Missouri Agricultural Experiment Station), photosynthesis (North Carolina Agricultural Experiment Station), nucleic acids (Indiana Agricultural Experiment Station), and rapid methods of determining amino acids (Arthur D. Little Inc.) are in effect.

The scientific effort devoted to research in this area totals 27.9 professional man-years. Of this number 7.6 is devoted to breeding and genetics; 7.8 to diseases; 2.6 to culture; 3.7 to quality; 6.2 to physiology. Extramural agreements account for 3.9 man-years of the above as: .1 breeding and genetics; .9 diseases; .8 quality; and 2.1 physiology.

PROGRAM OF STATE EXPERIMENT STATIONS

A total of 51.9 professional man-years, is devoted to this area of research.

PROGRESS--USDA & COOPERATIVE PROGRAMS

A. Breeding and Genetics

1. Breeding

a. New Varieties. The variety 'Traverse' is adapted to Minnesota, northern Iowa, and South Dakota. Traverse is superior to Chippewa, has colorless hila and is resistant to seed coat mottling.

The variety 'Amsoy' was released to certified growers of Illinois, Indiana, Iowa, Minnesota, Missouri, Nebraska, and South Dakota. Amsoy is superior in yield and oil content to any presently grown adapted varieties.

'Semmes' was released in the Mississippi Delta region and does best on the clay soils. Semmes is resistant to phytophthora rot and yields 8% greater than Lee on clay soils.

'Davis' is adapted to the clay soils of the northeast Arkansas. Released in Arkansas, Davis is also resistant to phytophthora rot.

'Dare' is a variety adapted to the Mid-Atlantic and upper Mississippi Delta area. Dare is resistant to purple seed stain and mottling. It is also resistant to the leaf diseases bacterial pustule, wildfire, and target spot, and moderately resistant to phytophthora. Yield has been about 8% above presently grown varieties and about 2 days earlier.

b. Cyst nematode resistant varieties. 'Pickett', a yellow-seeded cyst-nematode resistant variety was released. Recommended for growing in cyst nematode infested soil. Released in Arkansas, Missouri, North Carolina, Tennessee, and Virginia. Lines earlier than Pickett and having resistance to other pathogens are in the advanced stages.

c. Breeding for disease resistance. Present efforts are to incorporate into advanced material resistance to several pathogens. Incorporation of cyst nematode, root knot nematode and phytophthora root rot resistance has been accomplished and is in advanced line test. For the Midwest, incorporation of phytophthora, bacterial pustule, and frogeye, race 2 resistance into a desirable agronomic type is being attempted. Evaluations are continuing in search of resistance to the brown stem rot organism, Cephalosporium gregatum. Plant introductions were evaluated at 5 locations in the Mid-Atlantic States in a search for material having good seed quality.

d. Improved protein. Crosses involving high protein genotypes have been made. Preliminary results indicate some increase in protein can be made without a large decrease in oil. Advance material with approximately 3% more protein than presently grown varieties at a yield level equal to present varieties is planned for release in 1967.

Germplasm was screened for variability in methionine, the amino acid which becomes limiting first. There was a slight tendency for methionine content to increase with lateness of maturity.

e. Oil improvement. Using gas-liquid-chromatography (GLC) and Beckman spectrophotometric analysis, 1200 soybean varieties and strains were screened for percentage of linolenic and linoleic acid in the oil. No samples of less than 4.5% linolenic acid were found. However, there were samples with about 60% linoleic acid content.

f. Methods of breeding. Results of Uniform Regional trials from 1954-56 were analyzed to evaluate genotype x environmental interactions. Results indicated that regional testing for yield in more than 30 environments gives very little increase in precision. This suggests a practical testing limit of 3 years and 10 locations each year. For more highly heritable traits as few as 10 environments gave satisfactory precision.

Studies are also underway to devise a method of evaluation of soybean genotypes so that the individual performance of a variety is more efficiently measured and in addition information obtained as to the competitiveness of the genotype.

From studies of homogeneous daughter lines and heterogeneous maternal lines, it was determined that genetically heterogeneous lines showed greater stability across environments and lower variance within environments than did homogeneous lines. This indicates a heterogeneous population is a better buffer against environmental variability.

General selection indices closely approached specific indices in predicted advance and were also approximately as efficient as specific indices in obtaining actual yield advance.

Specific gravity for separating seed of varying oil content has been used successfully in several programs. Results indicated 4 cycles to be effective in separating genotypes into high- and low-oil components.

Attempts are being made to use tobacco ringspot virus (TRS) as an aid in producing hybrid seed. By infecting the female parent natural crossing can be increased. Megagametogenesis studies indicate that TRS affects pollen viability.

2. Genetics. Inheritance of dwarfness in the varieties Adams and Lincoln indicated that the dwarf types are Df_2, Df_2, df_3, df_3, and df_2, df_2, Df_3, Df_3, respectively. Therefore, any genotype homozygous for Df_2 or Df_3 or both will be a dwarf.

Numerous backcrosses were made and are being evaluted to determine relationship between height and maturity; seed coat; pubescence and leaflet characteristics; and pigment traits.

Inheritance of symbiotic ineffectiveness of certain soybean genotypes to specific strains of rhizobium was found to be controlled by a single recessive gene.

B. Diseases.

1. Disease distribution. Diseases were present in all fields surveyed. The foliage diseases bacterial blight, bacterial pustule, downy mildew, and brown spot were the most prevalent. Brown stem rot, Cephaslosporum gregatum, was present in many fields and was reported for the first time in Texas. Phytophthora rot was found in fewer fields than in previous years, primarily due to the farmers growing resistant varieties.

2. Races and complexes of disease organisms. Reported variability among Pseudomonas tabaci of soybeans was found to be due to the confusion of P. tabaci with another species P. syringae. Fluorescent antibody technique,

serology, and host reaction continues to prove useful in characterizing strains of bacterial diseases. Work initiated in 1964 on pod mottle virus (PMV) and soybean mottle virus (SMV) was continued. Doubly infected plants consistently had greater PMV titres in their stem apices when inoculated first with SMV and 1 week later with PMV than plants inoculated in the reverse order. Investigation on frogeye leafspot revealed two new physiological races of Cercospora sojina with pathogenic abilities to attack the principal soybean varieties in the Southeast. The true asexual stage of brown stem rot was discovered. The true stage is a synnema. This identifies the organism as a species of Stilbella.

3. Phytophthora rot studies. Distribution host range of Phytophthora megasperma was investigated. Race 2 was found widely distributed in the alluvial soils of Arkansas and Mississippi. Roots of plants susceptible to stem inoculation were found to be resistant to race 2. Studies in Illinois indicated the less virulent P. cactorum would offer some cross protection to a later infection of P. megasperma.

4. Environment factors and disease susceptibility. Reduced light intensity apparently does not affect the pathogenicity of the phytophthora rot. However, high temperature does. The resistant variety, Harosoy 63, was susceptible when held at 43°C for a minimum of 3 days. Field survey and laboratory experiments indicate the distribution of the bacteria Pseudomonas tabaci may be related to the minimum temperature.

5. Search for disease resistance. Hundreds of genotypes of introductions and lines from segregating populations were screened in search for agronomically desirable types resistant to frogeye leaf spot, downy mildew, tobacco ringspot, and Phythium ultimum. At present no good resistance has been found to brown stem rot. Where resistance or tolerance is available efforts are being made to incorporate these into resistant varieties. Screening of material is continuing to identify material with good seed quality resulting from a complex of diseases.

6. Microorganisms associated with seed. From 1232 seed samples (1964), eleven cultures of Aspergillus flavus were obtained. Two isolates were tested for toxin production. One did not produce any detectable aflatoxin and the other produced 100,000 ppb of B_1 component. No culture of A. flavus was isolated from 1965 material.

C. Culture

1. Growth regulators. The growth regulator tri-iodobenzoic acid (TIBA) was evaluated at locations in the Northcentral United States, and the Mississippi Delta area. The results were variable but in general indicated no dependable yield advantage to applications of the chemical.

2. Row spacing. Row spacing trials in the North indicated an advantage in reducing row width from 40" to 20". In the South, there was no advantage

to close rows. Iowa and Indiana trials of TIBA at various row widths indicate from slight to no advantage with the chemical in narrow rows.

3. Nodulating-bacteria studies. As indicated in previous years, 25 to 50 times the normal amounts of Rhizobium japonicum inoculum must be applied to obtain recovery of an applied bacterial strain. At 50 times the normal rate using gum arabic as a sticking agent in pelleting the inoculum on the seed average recovery of 44% of the applied inoculum was obtained. There was an indication that recovery is dependent upon the strain applied and its adaptability to the particular soil environment.

Bacterial strain tests were conducted at two locations in Maryland and at Ames, Iowa. Results indicated an interaction between a genotype of soybeans and a strain of bacteria. For example, on a two-year average in Iowa, the variety Amsoy yielded highest with R. japonicum strain 6, while the genotype A62-3 yielded lowest. The first year of a 3-year study designed to measure competition and survival was completed. Differential competition and performance was measured among the three strains used. Under a PL 480 project, nodules have been collected in India to be compared with U. S. strains of known competitiveness. Data from nodules sampled from uninoculated seed of soybean genotypes planted at Beltsville indicate that the soybean genotype is selective as to the strains of rhizobium that will be allowed to induce nodule formation. The serological distribution was significantly different among the genotypes evaluated.

D. Quality

The use of NMR (nuclear magnetic resonance) spectrometry evaluation for oil content in routine oil analysis increases the number of samples that can be evaluated. It also presents the possibility of reducing generation time. This is primarily because NMR analysis does not destroy the seed and that it can be used on a small sample size. Data indicate a correlation of .972 between NMR and official A.O.C.S. determinations of oil content of whole beans.

GLC (Gas-liquid-chromatography) analysis of soybean oil was conducted to evaluate variability of soybean fatty acids. Variability was indicated and breeding and genetic studies initiated.

Fatty acid synthesis studies in the developing cotyledon indicated a definite dependence on ATP and bicarbonate indicating the "de novo" synthesis of fatty acids. The system is also dependent upon TPNH.

Feeding trials conducted using the higher protein genotypes indicated no adverse effect on the growth of chickens.

E. Physiology

1. Nutrient relationships. The time and rate of dry matter accumulation

in different plant parts of large- and small-seeded soybean varieties was measured. The maximum rate of dry matter accumulation in the plants was about 125 pounds/acre/day and maximum accumulation in the beans was 100 pounds/acre/day. Tentatively no differences were noted in accumulation in large- and small-seeded varieties.

Nodulating and non-nodulating lines were used in an outdoor gravel experiment to measure the uptake of nutrient under low and adequate amounts of N. The non-nod line adsorbed more NO_3 than the nod, and at the level of adequate NO_3 for the nod line the non-nod line became nitrogen-deficient. There was a good correlation between K uptake and yield in all treatments and good agreement between P absorption and yield at the high N treatments.

Foliar sprays of urea, $NaNO_3$ or $(NH_4)_2NO_3$ were applied at early bloom and early pod set. No yield increases were obtained from foliar application. In fact, $NaNO_3$ reduced yield 20%. Side dressing $NaNO_3$ at 200#/a, increased the yield of the non-nodulating line from 26.7 to 36.7 bu/a. Increase of the nodulating line was from 38.9 to 41.3 bu/a.

2. Metabolic studies. The enzyme nitrate reductase (NR) was investigated throughout the season. Observations suggested that the NR enzyme is associated with, if not limited to, the vegetative phase of growth. Appreciable NR activity was found only in young expanding or recently expanded leaves in flowering and podding plants even though the actual nitrate level is higher in the older leaves.

3. Plant community studies. Using two varieties differing in canopy density, determinations were made on solar absorption and morphology. More light penetrated to an 18 inch depth in the less dense canopy. Morphologically, the less dense canopy was characterized by smaller terminal leaf angle, smaller petiole angle, shorter petiole, and less leaf area. It is suggested that the deeper penetration of sunlight may have resulted in the greater seed set and seed weight of the less dense canopy.

PUBLICATIONS--USDA AND COOPERATIVE PROGRAMS

Breeding and Genetics

Brim, C. A. 1966. A modified pedigree method of selection in soybeans. Crop Sci. 6(2):220.

Brim, C. A. 1966. Registration of Dare soybeans. Crop Sci. 6(1):95.

Brim, C. A., and J. P. Ross. 1965. Pickett, a cyst nematode resistant soybean strain. Soy. Dig. 25(11):16-17.

Brim, C. A., and J. P. Ross. 1966. Relative resistance of Pickett soybeans to various strains of H. glycines. Phytopath. 56(4):451-454.

Caldwell, B. E., and C. R. Weber. 1965. General, average and specific selection indices for yield in F_4 and F_5 soybean populations. Crop Sci. 5:223-226.

Probst, A. H., K. L. Athow, and F. A. Laviolette. 1965. Inheritance of

resistance to Race 2 of Cercospora sojina in soybeans. Crop Sci. 4:332.
Weber, C. R. 1966. A new soybean -- it's Amsoy. Soy. Dig. 26(4):22-23.

Physiology

Weber, C. R., and B. E. Caldwell. 1966. Effects of defoliation and stem bruising on soybeans. Crop Sci. 6:25-27.
Weber, C. R., R. M. Shibles, and D. E. Byth. 1966. Effect of plant population and row spacing on soybean development and production. Agron. J. 58(1):99-102.

Diseases

Brim, C. A., and J. P. Ross. 1965. Pickett - a cyst nematode resistant soybean. Soy. Dig. 25(11):16-17.
Brim, C. A., and J. P. Ross. 1966. Relative resistance of Pickett soybeans to various strains of Heterodera glycines. Phytopath. 56(4):451-454.
Chamberlain, D. W., and J. W. Gerdemann. 1966. Heat-induced susceptibility of soybeans to Phytophthora megasperma var. sojae, Phytophthora cactorum, and Helminthosporium sativum. Phytopath. 56(1):70-73.
Dunleavy, J. M. 1965. Downy mildew of soybeans. Soy. Dig. 24(4):17.
Dunleavy, J. M. 1966. Brown stem rot in soybeans. Iowa Farm Sci. 20(10): 3-4.
Dunleavy, J. M. 1966. Factors influencing spread of brown stem rot of soybeans. Phytopath. 56(3):298-300.
Dunleavy, J. M., J. F. Kunkel, and J. J. Hanway. 1966. High populations of Bacillus subtilis associated with phosphorus toxicity in soybeans. Phytopath. 56(1):83-87.
Morgan, F. L., and E. E. Hartwig. 1965. Physiologic specialization in Phytophthora megasperma var. sojae. Phytopath. 55:1277-1279.
Morgan, F. L., E. E. Hartwig, and R. W. Howell. 1966. Phytophthora rot of soybeans on the High Plains of Texas. Pl. Dis. Rep. 50(2):104-105.
Probst, A. H., K. L. Athow, and F. A. Laviolette. 1965. Inheritance of resistance to Race 2 of Cercospora sojina in soybean. Crop Sci. 4:332.
Ross, J. P. 1965. Effect of infection sequence of beanpod mottle and soybean mosaic virus on host reaction and virus titers in doubly infected soybean shoot apices. Phytopath. 55:1074. (Abstract).
Ross, J. P. 1965. Nematodes increase Fusarium wilt in soybeans. Crops and Soils 17(9):25.

Cultural Practices

Weber, C. R. 1966. Nodulating and nonnodulating soybean isolines: I. Agronomic and chemical attributes. Agron. J. 58:43-46.
Weber, C. R. 1966. Nodulating and nonnodulating soybean isolines: II. Response to rates of applied nitrogen with modified soil conditions. Agron. J. 58:46-49.

PUBLICATIONS--STATE EXPERIMENT STATIONS

Caviness, C. E. 1965. Effects of relative humidity on pod dehiscence in soybeans. Crop Sci. 5(6):511-513. (Ark.)

Fiskell, J. G. A., Kuell Hinson, and H. W. Lundy. 1964. Leaf composition and yield of several soybean genotypes. Proc. Soil and Crop Sci. Soc. of Florida 24:220-231. (Fla.)

Gillespie, G. A., and J. B. Bancroft. 1965. The rate of accumulation, specific infectivity, and electrophoretic characteristics of bean pod mottle virus in bean and soybean. Phytopath. 55:906-908. (Mo.)

Greer, H. A. L., and I. C. Anderson. 1965. Response of soybeans to Triiodobenzoic acid under field conditions. Crop Sci. 5(3):229. (Iowa.)

Harris, H. B., M. B. Parker, and B. J. Johnson. 1965. Influence of Molybdenum content of soybean seed and other factors associated with seed source on progeny response to applied Molybdenum. Agron. J. 57(4): 397. (Ga.)

James, A. L., I. C. Anderson, and H. A. L. Greer. 1965. Effects of Naphthaleneacetic acid on field-grown soybeans. Crop Sci. 5(5):472-474. (Iowa)

Knox, J. N., J. L. Morrison, A. H. Probst, and E. T. Mertz. 1965. The unusual chromatographic pattern of Adams soybean whey proteins. Cer. Sci. Today 10(4):150. (Abstract). (Ind.)

Lambe, R. C., and J. M. Dunleavy. 1965. A new disease in Iowa cornfields. Iowa Farm Sci. 19(9):3-4. (Iowa.)

Matson, A. L., and L. F. Williams. 1965. Evidence of a fourth gene for resistance to the soybean cyst nematode. Crop Sci. 5:477. (Mo.)

Millikan, D. F., T. D. Wyllie, and E. E. Pickett. 1965. Some comparative biochemical changes associated with downy mildew infection in soybeans. Phytopath. 55:932. (Mo.)

Pardee, W. D., R. L. Bernard, E. L. Smith, and W. O. Scott. 1966. Soybean varieties for Illinois for 1966. U. of Ill. Circ. 929. (Ill.)

Shibles, R. M., and C. R. Weber. 1966. Interception of solar radiation and dry matter production by various soybean planting patterns. Crop Sci. 6:55-59. (Iowa.)

Shibles, R. M., and C. R. Weber. 1965. Leaf area, solar radiation interception and dry matter production by soybeans. Crop Sci. 5(6):575-577. (Iowa)

Starnes, W. J., and H. H. Hadley. 1965. Chlorophyll content of various strains of soybeans, Glycine max (L.) Merrill. Crop Sci. 5(1):9-10. (Ill.)

OILSEED BREEDING, GENETICS, DISEASES, VARIETY EVALUATION, CULTURE AND PHYSIOLOGY, AND QUALITY
Crops Research Division, ARS

Problem. Seven oilseed crops with a wide range of uses and production problems are covered by this area. Crops included are: safflower, peanuts, flax, castorbean, sesame, sunflower and tung.

Breeding lines and the required techniques to produce commercial hybrid safflower have been developed. The urgent problem is to test the feasibility of the techniques and the performance of inbred varieties on a scale suited to the production of F_1 seed for commercial planting. Disease resistance, reduced hull, higher oil and protein content, and yield will be important considerations.

With peanuts, principal problem is a need to lower the cost of production and improve quality. More precise information is needed on (1) control of destructive diseases, especially those caused by soil-borne microorganisms, including toxin-producing molds, and those caused by viruses; (2) the physiology of the plant, mineral nutrition, and environmental factors affecting growth, and flowering and fruiting; (3) breeding behavior of the crop; and (4) identifying and measuring characteristics of peanuts associated with quality for specific end uses. Improved varieties are needed with higher yield, resistance to diseases and insects, adaptation to mechanical harvesting, improved shelling and processing characteristics, increased market acceptability, and enhanced nutritional and keeping properties.

The average yield of flaxseed is low and means of raising the national average are needed urgently to reduce the cost of production and assure the continued use of linseed as an industrial oil. Hybrid flax is a possibility and substantially increased yields may be expected if the problems of pollen transfer from male to female lines can be effected. Methods to transfer genes for resistance to pasmo and the virus diseases from wild species to cultivated flax need to be developed.

The use of F_1 hybrids in castorbean production has increased substantially. Improved inbred lines with superior combining ability that will transmit high seed yield, high oil content of the seed, disease resistance, and good agronomic characters are needed.

The large requirement of hand labor to produce sesame has limited production severely. To provide wide acceptance of sesame as a crop, it will be necessary to breed improved indehiscent lines with higher yield, improved threshability, higher seed quality, resistance to disease and adaptation to complete mechanical harvesting.

Sunflower production is handicapped by lack of resistance to insects and diseases. Genetic resistance to disease and insect pests would go far

to make the commercial production of sunflower seed profitable.

Methods are needed, either chemically to keep tung trees dormant to avoid spring frosts, nutritionally or culturally to make trees more cold hardy, or through breeding to find or develop a more cold hardy or later blooming clones. More information on spacing, nutrition, cultural practices, and variety testing is needed to enable more consistent and high production at less cost.

USDA AND COOPERATIVE PROGRAM

The Department has a continuing long-term program involving geneticists, pathologists, biochemists, physiologists, agronomists and horticulturists engaged in both basic and applied research leading to the solution of growers' problems.

Safflower breeding, disease, and cultural research is being carried on in cooperation with the Arizona, California, Nebraska, and Utah Agricultural Experiment Stations and at Beltsville, Maryland. The nature of resistance to safflower diseases is being carried under cooperative agreement with the California Agricultural Experiment Station. The structure of the safflower seed with particular reference to the pigmented (melanin) layer and other structures of the seed coat is being studied under cooperative agreement with the Arizona Agricultural Experiment Station. A PL 480 program has been initiated in Israel to study the resistance of lines in the World Collection to insects and diseases.

Peanut breeding and variety evaluation research and peanut disease investigations are cooperative with the Georgia, North Carolina, Oklahoma, and Virginia Agricultural Experiment Stations. Disease, culture, seed physiology, and variety evaluation research are cooperative with the Alabama Agricultural Experiment Station. Peanut variety evaluation and seed physiology research are carried on at Beltsville, Maryland. Peanut mycotoxin research is conducted under contract with Alabama, Georgia, North Carolina, Oklahoma, and Texas Agricultural Experiment Stations; under cooperative agreements with the Georgia and Virginia Agricultural Experiment Stations; and under a grant with the Minnesota Agricultural Experiment Station. Peanut gnotobiotic research is conducted under a grant with the Colorado Agricultural Experiment Station. Peanut rust and variety and strain adaptation research are carried on at Mayaguez, Puerto Rico. Research on range of genetic variability in tocopherols of diverse peanut germ plasm is being conducted under contract at Menlo Park, California. Peanut research is being conducted under three 5-year PL 480 contracts: in India on range of genetic variability in United States' and India's diverse peanut germ plasm, and on physiology of cell particulates; a third, in Israel, involves study of the biology of the fungus Aspergillus flavus as it affects peanuts.

Flax research is conducted cooperatively with the Minnesota, North Dakota, and South Dakota Agricultural Experiment Stations, and at the Southwestern

Irrigation Field Station, Brawley, California. The nature of resistance to flax rust is being investigated under contract with the North Dakota Agricultural Experiment Station. Effects of irradiation of flaxseed are being supported by contributed funds from the Atomic Energy Commission.

Castorbean breeding, genetics, disease control, and cultural trials are being carried on in cooperation with the Texas Agricultural Experiment Station. Sesame research is in cooperation with the Texas Agricultural Experiment Station and at Beltsville, Maryland. Sunflower research on breeding for resistance to insect and disease pests is in cooperation with the Texas Agricultural Experiment Station.

Tung research is carried on at one central field location at Bogalusa, Louisiana, with a field laboratory at Monticello, Florida. The work is cooperative with the Experiment Stations of Mississippi and Louisiana. Much of the field work and experimental plantings are at the Mississippi Experimental Tung Farm, Poplarville, Mississippi.

The Federal scientific effort devoted to research in this area totals 35.6 professional man-years. Of this number 10.1 are devoted to breeding and genetics; 12.1 to diseases; 3.7 to variety evaluation; and 8.2 to culture and physiology, and 1.5 to quality.

PROGRAM OF STATE EXPERIMENT STATIONS

A total of 29.8 professional man-years is devoted to this area of research.

PROGRESS--USDA AND COOPERATIVE PROGRAM

A. Breeding and Genetics

1. Safflower. Ute a high yielding rust-resistant variety was named and released in cooperation with the Utah Agricultural Experiment Station. This variety has been highest in yield at Logan, Utah for the past three years, averaging 17 to 22 percent more seed than US-10, Gila, or Frio. Frio was released in 1965 in cooperation with the Arizona Agricultural Experiment Station. This variety has yielded slightly more than Gila in USDA trials in Arizona; it is more resistant to Phytophthora root rot; is more cold tolerant; and has slightly higher oil content.

Breeding for rust resistance has progressed with selection in segregating populations. Newer and more effective genes for resistance are being incorporated in commercial varieties and experimental breeding lines.

The commercial use of hybrid safflower is a distinct possibility. Thin-hull lines that are delayed in pollen shed are used as females. Three new thin-hull lines with superior plant type have been selected for testing.

2. Peanuts. Natural Crossing. Evidence of uni-directional natural crossing, obtained by use of seedling genetic marker at 5 research locations in the 3 Southeastern Peanut Belt States in 1965 confirms 1964 results indicating a low but persistent level of natural outcrossing in peanuts in the Georgia-Florida-Alabama area. Overall 1964-65 average was 0.99 percent, with a range of 0.68 to 1.85 percent.

At Tifton, Georgia, most peanut flowers are visited repeatedly by bees on the day the flowers open. Although evidence indicates that bees are responsible for natural crossing, bee visitation of flowers at Tifton obviously is not a limiting factor in the generally low level of natural crossing that occurs there. In the presence of bee visitation of peanut flowers, something inherent in the floral biology of the plant apparently determines the level of natural crossing at this location.

Root worms feeding preference. In contract research and research under cooperative agreements, adults and larvae of the highly destructive southern corn root worm showed a preference for certain varieties of peanuts under field and laboratory conditions. However, when plants or plant parts of only "non-preferred" varieties were available, the root worms fed on them. Whether this apparent lack of preference of root worms for certain varieties when a choice of several varieties is available, is an indication of usable genetic resistance to root worms under field conditions where only one variety is present has yet to be determined.

3. Flax. Rust Resistance. The race 300 of flax rust was found to have spread throughout the North Central flax growing region. Losses from rust infection were negligible, however, because most of the flax acreage was sown to rust-resistant varieties. In contrast to this, serious losses resulting from rust infection are anticipated in the flax growing area of Southern Texas. There approximately 80 percent of the acreage was sown to DeOro, which is susceptible to the relatively new rust race 297. Well-adapted rust-resistant varieties are available to the Texas growers; however, many choose to sow DeOro, contrary to recommendation of the Texas Agricultural Experiment Stations.

Varietal Mixtures. Mixtures of two or more flax varieties have been more productive than the varieties sown alone during the past four years when growing conditions were sub-optimum. The advantage of mixtures over single varieties is inversely related to the average yields with a significant correlation coefficient of -.42. Since much of commercial flax is grown under sub-optimum conditions (average yields of 10 to 14 bu/acre), use of certain variety mixtures would likely benefit flax production.

Natural Selection. The effects of natural selection upon maturity and seed quality of six heterogenous bulk populations did not differ markedly between four different locations in Minnesota. Selection sites did appear to affect the frequencies of high-yielding genotypes, however. Populations grown continuously for four years at Lamberton were significantly lower yielding,

relative to checks, than were populations grown 4 years at Morris.

Hybrid Flax. A program to develop, by backcrossing, male-sterile (cytoplasmic) lines of adapted flax varieties is continuing. Satisfactory fertility-restorer genes are being incorporated into lines of adapted varieties. Natural pollination of male-sterile flax by adjacent male-fertile flax occurs at low frequencies in field nurseries at St. Paul, Minnesota. Though the degree of pollination is low, open-type male-sterile flowers are pollinated more frequently than closed-type male-sterile flowers.

Irradiation Studies. Recurrent irradiation of flax has resulted in about 150 chlorophyll and 200 flower color mutants. These new characters are of value for biochemical studies and mapping flax chromosomes. Intercrossing the mutants has shown that some of them are either duplicates or alleles.

Interspecific Hybridization. In order to extend the range of germ plasm available for seedflax improvement, inter-specific hybridizations between many wild Linum spp and Linum usitatissimum were attempted. By using embryo culture technique, over half of 61 crosses attempted were successful. One cross, L. grandiflorum (red-flowered) X L. usitatissimum, which has been attempted unsuccessfully many times before, resulted in a vigorous F_1 plant which failed to flower.

4. Castorbean. Fifteen castorbean breeding lines developed for resistance to capsule drop and high oil content were released to castorbean breeders in cooperation with the California Agricultural Experiment Station. Five breeding lines developed in Mississippi and tested in Texas were released to breeders in cooperation with the Mississippi and Texas Agricultural Experiment Stations. These five lines are among the most resistant to capsule mold and capsule drop. The twenty lines included in the two releases are expected to provide superior male lines to add high oil and resistance to capsule mold and drop to F_1 hybrid seed for commercial planting.

The male sterile line CNES-1, recently released to commercial castorbean breeders, has provided a source for further improvement of the environmental sensitive type of pistillateness. In yield trials of experimental F_1 hybrids in Texas many of the high-yielding hybrid combinations used female lines related to CNES-1.

The two varieties Lynn and Hale developed in the cooperative program continue to produce top yields among inbred varieties and are used almost exclusively as male parents in the production of F_1 hybrid seed. Improved breeding lines have been selected from Lynn that are higher in yield than the original variety.

A study of natural crossing on the High Plains indicates 65 to 81 percent outcrossing depending upon the degree of exposure to foreign pollen.

5. Sesame. Breeding work with sesame was greatly reduced in 1965 and limited to testing and evaluation of the most promising advanced breeding lines. Two lines with strong placenta attachment, that reduced shattering of seed, yielded 1626 pounds per acre compared to 978 pounds for the commercial check variety, Oro.

Forty-six out of 47 lines resistant to Race 2 of bacterial leaf spot produced a higher seed yield than the Margo check.

6. Sunflower. Susceptibility to damage by the sunflower head moth has been a limiting factor in commercial production in the southern and western parts of the United States. Screening for resistance under heavy infestation indicates certain inbred lines are resistant, or at least less susceptible, to the insect. Damage to the most resistant lines averaged 5 to 10 percent, while susceptible lines were damaged from 95 to 100 percent. Further evidence for genetic resistance was indicated by a clear-cut segregation in F_3 lines. A wild species, Helianthus petiolaris, was essentially immune. Three hybrids between the wild species and cultivated sunflower were intermediate in resistance, but unfortunately were highly sterile.

Four types of male sterility have been identified and the usefulness of each type in making F_1 hybrid and for commercial planting is being investigated.

7. Tung. Breeding for late blossoming and cold hardiness. Selection BR-363, an Aleurites montana X A. fordii hybrid, blooms late, is moderately productive, has medium oil content, and considerable winter hardiness.

Buds on abscised shoots of 14 late-blooming and 2 standard clones were forced in the greenhouse at 75° F. after various lengths of storage ranging from 0 to 672 hours at 50° F. Buds of clone BR-363 exposed to as much as 672 hours, and M-185 exposed to 504 hours, at 50° F. failed to break after 8 weeks forcing; whereas, standard varieties Isabel and La Crosse forced readily after 5 and 7 weeks, respectively, after 504 hours chilling.

Genetic studies. Meiotic analyses revealed irregularities in pairing and variation in numbers of univalent and bivalent chromosomes at the first metaphase and lagging chromosomes at both first and second divisions of meiosis that contribute to nonviable gametes, causing sterility.

B. Diseases

1. Safflower. Rust. Ute, a rust-resistant variety, and 16 rust-resistant breeding lines have been shown to represent several unrelated genetic sources of resistance, and were released in cooperation with the Utah Agricultural Experiment Station. Genetic analysis is incomplete, but resistance in some lines has been shown to be inherited as a simple dominant. These genes could be incorporated into commercial varieties

easily by backcrossing, or they could be used as male parents in the production of F_1 hybrids.

Phytophthora. Phytophthora has been a serious disease of safflower. Resistance has been found and incorporated into commercial varieties. The highest resistance has been designated as the "Biggs" level. A study of the nature of the Biggs level of resistance has shown that resistance is associated with a high content of water-insoluble pectic compounds and calcium in fresh hypocotyls.

Virus Diseases. Certain varieties of safflower have been shown homozygous for local lesion reaction to lettuce mosaic virus on inoculated leaves.

Fusarium. Wilt caused by Fusarium oxysporum f. carthami has become a serious disease of safflower in parts of California. Resistance has been found in N6 and a backcrossing program has resulted in resistant lines similar to Frio. These will be increased and tested for field resistance.

2. Peanut. Pre-harvest Death. In Georgia abrupt pre-harvest plant death of peanuts in 1965 was related to genotype. This crippling disorder was tentatively attributed to systemic invasion by Sclerotium bataticola. About one-third of the commercial peanut acreage in Georgia is planted with varieties that died prematurely.

Bacterial Wilt. In Georgia under conditions of controlled inoculation, varieties of peanuts reacted differently to different isolates of Pseudomonas solanacearum, which causes bacterial wilt. No variety was resistant to all isolates. Schwarz 21, which is reported as resistant to bacterial wilt in Indonesia, was moderately susceptible to one isolate.

Pod rot. Heavier than normal applications of landplaster (1500 to 3000 pounds per acre) continued to suppress pod rot and increase yield and quality of peanuts in Virginia in 1965. Calcium in the landplaster has been shown to be primarily responsible for the suppression of the disorder. Rhizoctonia was more prominent in the pod rot complex in Virginia in 1965 than in previous seasons.

Stem rot. In Virginia, in 1965 results confirm previous findings that under field conditions, types and varieties of peanuts differ in apparent susceptibility to stem rot, caused by Sclerotium rolfsii. Valencias (Tennessee Red) were the most susceptible, followed closely by Spanish, with Virginia type varieties the least susceptible. However, all types and varieties were vulnerable to the disease. The recommended practices of permanent deep burial of surface trash in initial land preparation and non-dirting cultivation effectively controlled stem rot in all types and varieties.

In research at Auburn, Alabama, on the influence of plant residues and soil microorganisms on the saprophytic and parasitic activities of Sclerotium rolfsii, evidence indicates that oat residues may have both direct and indirect deterring effects upon the saprophytic and pathogenic activities of the fungus. Water soluble substances from oat residues tend to inhibit the fungus and/or induce increased populations of soil microorganisms which may destroy mycelium of the fungus or suppress sclerotium germination. Trichoderma viride was shown to be an effective inhibitor of S. rolfsii, and evidence indicates that bacteria may be equally as effective or more so.

Peanut Stunt. During 1965 a highly destructive new stunt disorder of peanuts became apparent in commercial fields in several counties in Virginia and North Carolina. The disorder is caused by a virus which is highly infectious, easily transmitted mechanically, and has a wide host range among both cultivated and wild plants, including legumes and nonlegumes. In certain fields and parts of others 70 to 80 percent of the peanut plants were severely stunted, and yield of marketable pods on severely stunted plants was near zero.

Preliminary results at Beltsville, Maryland, indicate that seed transmission in seed that are large enough to be included in peanut planting stock is quite low, and yield of seed of this size on severely diseased plants is also quite low.

No immunity to stunt has been detected in more than 350 varieties, advanced breeding lines, and introductions of peanuts checked at Beltsville. Some evidence of possible differential tolerance to stunt has been observed under greenhouse conditions.

Pod and Seed Fungi. A wide variety of fungi became intimately associated with peanut pods and seed in the early stages of their development in the soil, as the crop matured and was harvested, and during and following curing. These preliminary results were obtained in a belt-wide survey of pod and seed microflora in 1965 under contracts and cooperative agreements with Agricultural Experiment Stations in Alabama, Georgia, North Carolina, Oklahoma, Texas, and Virginia. Principal fungi found were species of Fusarium, Penicillium, Aspergillus, Trichoderma, Thielevia, Chaetomium, Curvularia, Rhizoctonia, Rhizopus, Alternaria, Diplodia, and Sclerotium bataticola.

Fungi present and their relative prevalence tended to change as the fruits developed and matured in the soil. Under some circumstances, decided changes in incidence and prevalence occurred following digging and during curing. Species of Fusarium and Penicillium were prominent at all locations. Otherwise the composition of the fruit microflora and prevalence of the components tended to vary somewhat from area to area, State to State, and geographic location within a State.

Preliminary results indicated no consistent association of the occurrence or prevalence of fungi in seed or pods with variety, soil type, crop rotation, cover crops, fertilizer, landplaster, or different types of land preparation. Results suggested that pod and seed microflora might be influenced somewhat by irrigation or soil fungicides.

Mycotoxin Research. Aspergillus flavus was isolated from developing peanut fruits, with frequency varying from occasional up to 50 percent, in Alabama, Georgia, Texas, and Virginia; rarely in Oklahoma; and not at all in North Carolina. A. flavus was found in seed of cured peanuts in all States except Oklahoma at levels ranging from negligible up to 80 percent. A high proportion of the isolates of A. flavus were found to be capable of producing aflatoxin under conditions favorable for aflatoxin production.

Certain samples of cured experimental peanuts from all 6 States were found to be contaminated with aflatoxin. Aflatoxin was found rarely in peanut fruits prior to digging. Conditions under which the pods were cured strongly influenced development of aflatoxin. Mechanical injury of pods and seed by combine or other means appeared to make seed more susceptible to invasion by A. flavus and contamination with aflatoxin under conditions favorable for aflatoxin production.

Fungal microflora of peanut seed in Israel. In PL 480 research, cosponsored by Market Quality Research Division, peanut soils in Israel were found to sustain a rich varied microflora, more than 100 species of which have been identified. A. flavus was found to be a persistent member of this microflora, being present (at a low level) in every soil on every collection date over a 2-year period. A. flavus was found in a small proportion of seed of freshly dug plants; and in a much higher percentage of dry seed that had been in storage. Only an occasional sample of freshly dug peanuts was contaminated with aflatoxin. Stored peanuts showed higher contamination. About 70 percent of A. flavus isolates from soil, fresh seed, and stored seed was found to be capable of aflatoxin production.

3. Flax. Rust. Identification of 42 collections of rust obtained over the North Central flax growing area showed the general prevalence of races virulent to the host L gene (present in Marine, Arny, Sheyenne). There has been a marked build-up of races virulent to the host L^{10} gene (present in DeOro). Although new combinations of virulent genes were found in rust populations resulting from hybridization, no new genes for virulence were encountered.

Old and new accessions in the flax World Collection are being tested for the presence of rust-conditioning genes. Successive inoculations with different combinations of races has revealed new rust-conditioning genes or unusual combinations of genes. Test crosses are being made to identify the new or different sources of rust resistance. The rust reaction of Linore, a cold-tolerant variety developed for Willamette Valley, Oregon, appears to be due to the M gene plus at least one additional gene. The

latter conditions moderate resistance to North American races, and appears to be different from those previously studied.

Indole acetic acid (IAA) oxidase activity was found to decrease in seedlings of Bison inoculated with an avirulent race of rust. Another line of Bison, which was susceptible to the rust race, showed an increase in IAA oxidase activity within 5 hours after inoculation. Using 5 to 7 day-old flax seedlings and C^{14} labeled IAA, it was found that most of the IAA oxidase activity is in the cotyledon and little in the hypocotyl.

4. Castorbean. Botrytis. Three breeding lines possessing significantly more resistance to Botrytis capsule mold than Hale were identified under epiphytotic conditions in the field. These lines are F_8 selections from Baker 296 X Hale. Two closely resemble Hale and one resembles Baker 296. The lines are homozygous for visual characters and have good yield potential. Seed is being increased for extensive yield testing.

5. Sesame. Red root rot. Red root rot caused by Thielaviopsis basicola has been observed in many fields of sesame in Texas. Tests of varieties and breeding lines on a field heavily infested with the fungus at Beltsville, Maryland, failed to show any variety or line with a significant level of resistance.

6. Tung. Angular leaf spot (Mycosphaerella aleuritidis). Germ tubes of Mycosphaerella aleuritidis were found to enter the leaf through the stomata. The upper surface of the tung leaf has about 1, and the underside 100, stomates per square millimeter. A species of Macrophoma caused severe rotting of green fruit and a previously undescribed leaf spot was observed.

C. Varietal Evaluation

1. Safflower. A uniform irrigation test was grown at 5 locations in Nebraska and Colorado to test the feasibility of growing rust-resistant varieties under irrigation. Unfortunate circumstances prevented determining the potential at all but one location in Nebraska where an average yield of 2345 pounds per acre was obtained. The variety Ute, gave a disappointing performance in Colorado where it was extremely susceptible to Alternaria leaf spot, apparently predisposed by an unidentified root rot.

A rust-resistant line, U-1421-6-12 yielded 2938 pounds per acre under irrigation in Nebraska. Ute, which was not seriously attacked by either root rot or Alternaria produced 2276 pounds per acre.

2. Flax. Seven named and 13 experimental varieties were grown in regional trials in 9 States and 3 Canadian Provinces. All experimental varieties are resistant to North American rust races, including the new race 300. Most varieties combine a fair degree of resistance to wilt and some tolerance to pasmo. The varieties Dillman and Mac are very susceptible to pasmo, but a number of experimental lines show considerable improvement

over check varieties. Experimental lines 2290, 2292, 2444, and 2446 were high in yield compared with check varieties. These same varieties show a marked improvement in oil content over most named varieties.

3. Castorbean. Three hybrids using Lynn as the male parent gave the highest yield in an 8-variety trial in Texas. Lynn ranked 4th. The early maturity of Lynn plus its excellent combining ability makes it the most widely used male parent in commercial hybrid combinations.

4. Sesame. In 9 trials located in 5 States, SI 175, a dehiscent line with strong placenta attachment and resistant to race 2 of bacterial leaf spot, and SI 173, a large-seeded variety with similar disease resistance were the equal in yield to Oro and superior to Margo.

D. Culture and Physiology

1. Flax. Effect of Root Environment. Root environment was found to have important effects upon flax development when grown in controlled environment chambers and in a greenhouse. Increasing root zone volume caused a delay in senescence and an increase in seed size and oil yield. Seed size and oil content were reduced when root zone temperatures were increased, but seed and oil yield were not significantly affected.

Moisture Stress. Limiting moisture availability to roots grown in nutrient solution by the addition of polyethylene glycol had deleterious effects upon flax growth. At 10 atmospheres stress, there was a reduction of plant height and weight of plant, bolls, and seed. Moisture stress of 5 atmospheres had only slight growth retarding effects. Iodine value of oil was not affected by changes on moisture stress.

A factorial study was completed which involved (1) 3 varieties, (2) 2 temperatures, (3) 2 nitrogen levels, and (4) 3 boll-per-plant treatments. Increased ambient temperature hastened flowering but caused reductions in weight of plant and seed, seeds per boll, oil percent, and iodine value. Higher nitrogen level increased seed weight but reduced oil percent and iodine value. Reducing the number of bolls by pruning to 2 or 4 vs. 8 per plant resulted in increased seed size, and iodine value, delayed senescence and reduced oil content. Significant interactions between variety and the other 3 variables were observed.

2. Tung. Chemical protection against cold injury and frost. Loss of tung crops due to spring frost is a serious hazard to the industry. Research to find or develop chemicals to delay blossoming or increase hardiness indicates that 2-thiouracil, glycerol, and propylene glycol have potential value.

Mineral nutrition. Lithium chloride was readily absorbed but was toxic to tung seedling trees when applied at more than 5 grams per 8-inch pot.

On a calcium- and magnesium-deficient Lakeland fine sand low in pH at Compass Lake, Florida, magnesium sulfate, magnesium sulfate plus calcium carbonate, and calcined magnesite, caused a high leaf magnesium content. Increased yields in 1965 were associated with high leaf magnesium content rather than with leaf calcium content or soil pH.

Fertilizing under the spread of tung branches or in the entire space between the tree rows were similarly effective.

E. Quality

1. Peanut. Some peanut varieties contain 36 percent more protein than others. In PL 480 research on the range of genetic variability in our and India's extensive peanut germ plasm, mature seed of 48 entries grown in both countries in 1964 showed a range of 36 percent in protein (22.7 to 30.9) and 22 percent in oil content (44.3 to 55.2). Geographic location had no appreciable or consistent effect on either protein or oil of most entries. Of entries analyzed, Spantex was highest in protein, followed closely by Bynum Runner, an unusually large-seeded Virginia type that is not grown commercially. Although protein and oil tend to be negatively correlated in peanuts, varieties that are high in one are not necessarily low in the other.

Peanut varieties differ in content of tocopherols. In contract research, the application of improved procedures for determination of individual tocopherols in mature seed of 17 varieties of peanuts grown at Holland, Virginia, in 1964, has revealed some striking differences in both total tocopherol and in individual tocopherols among these varieties. Differences in tocopherol content cannot at present be related to any other known characteristic of or experience with these varieties. Possible relation of keeping time of oil to tocopherol content is under investigation.

Keeping time of peanut oil correlated with fatty acids in oil. Statistical analysis of data for 69 diverse peanut varieties grown at Tifton, Georgia, in 1964, revealed high, significant, positive correlations between (1) percent olein in oil and oil keeping time, and (2) iodine value and percent linolein; and high significant, negative correlations between (1) oil keeping time and linolein, (2) oil keeping time and iodine value, (3) iodine value and olein, and (4) olein and linolein. Results indicate that iodine value would be an excellent economical tool for initial screening of germ plasm to identify genotypes that are high or low in olein or linolein.

2. Flax. Endosperm and embryo tissues of mature flaxseed differed in the amount and the proportions of fatty acid they contain. The embryo contained three-fourths of total oil in the seed and nearly all the stearic acid. Palmitic and linolenic acid percentages were relatively high in the

endosperm as compared to the embryo. Seeds of three Linum spp (L. hispanicum, L. angustifolium and L. altaicum) differed from the above in that the endosperm was higher in stearic acid and lower in linolenic acid than was the embryo. An unusual fatty acid, tentatively identified as arachidic, was found to be present at levels of about 1% in seeds of the latter three species.

In vitro studies with immature flax embryo and endosperm tissues demonstrated fatty acid biosynthesis from acetate -1-C^{14} in both tissues. Oil synthesized by the embryo contained the greatest radioactivity in the linolenic acids; while in the endosperm tissue, the greatest activity was in the oleic acid fraction.

Preliminary study of the enzyme involved in fatty acid metabolism of flaxseed indicated it to be "lipodehydrogenase". Based upon more intensive studies of the enzyme, the term "hydroperoxide isomerase" more properly identifies the enzyme. The substrates for this enzyme are the conjugated diene hydroperoxides formed by the action of lipoxidase on linolenic or linoleic acids.

By using radioactive linoleic acid, it was shown that two compounds were formed as a result of enzyme activity. The major products are keto-hydroxy compounds, tentatively identified as 12-keto-13-hydroxy-octadec-cis-9-enoic acid and 9-hydroxy-10-keto-octadec-cis-12-enoic acid. The second group of compounds observed, in small amounts, are probably diketo or dihydroxy analogs of the compounds named above.

The presence of these keto-hydroxy fatty acid products, resulting from the enzyme activity of lipoxidase and hydroperoxide isomerase acting in stepwise manner upon linoleic or linolenic acids, has important implications. Their ability to be oxidized and reduced suggest that they may function in an electron-transport system as reactive intermediates which undergo further oxidation to produce short-chain fatty acids. The keto-hydroxy portion of these molecules is similar to the functional grouping in ascorbic acid, vitamin C. Whether these products function as a "lipid type" vitamin C will need to be learned from further experimentation.

3. Castorbean. Date of planting trials have indicated highest yields of seed are obtained from early planting. However, as an average for 2 years, average yields of over 2000 pounds per acre were obtained under irrigation at Lubbock, Texas, when a well-adapted early hybrid or inbred was used.

PUBLICATIONS--USDA AND COOPERATIVE PROGRAMS

Breeding and Genetics

Brigham, Raymond D. 1965. Inheritance of leafy raceme in castorbean (Ricinus communis L.). Crop Sci. 5:277-278.

Comstock, V. E. 1965. Associations between anther color of flax and several quantitative traits. Crop Sci. 5:282.
Comstock, V. E. 1965. Associations between petal color of flax and several quantitative traits. Crop Sci. 5:372.
Comstock, V. E., and C. E. Gates. 1965. Effectiveness of selection for seed quality characters in advanced generations of flax. Crop Sci. 5: 335-336.
Comstock, V. E., and J. H. Ford. 1965. "Flax" in varietal trials of farm crops. Minn. Agr. Expt. Sta. Misc. Rpt. 24, revised, pp.9-10.
Leuck, D. B., and R. O. Hammons. 1965. Pollen-collecting activities of bees among peanut flowers. Jour. Econ. Entom. 58:1028-1030.
Luciano, Aurelio, M. L. Kinman, and J. D. Smith. 1965. Heritability of self-incompatability in the sunflower (Helianthus annuus). Crop Sci. 5: 529-532.

Diseases

Culp, T. W., C. A. Thomas, and L. H. Zimmerman. 1966. Capsule diseases of castorbeans in Mississippi. Pl. Dis. Rep. 49:35-39.
Draper, A.D., and T. van der Zwet. 1965. Influence of age and size of tung leaves on susceptibility to angular leaf spot. Phytopath. 55(8) 926-927.
Flor, H. H. 1965. Inheritance of smooth-spore-wall and pathogenicity in Melampsora lini. Phytopath. 55:724-727.
Flor, H. H. 1965. Tests for allelism of rust-resistance genes in flax. Crop Sci. 5:415-418.
Garren, K. H. 1966. Peanut (groundnut) microfloras and pathogenesis in peanut pod rot. Phytopath. Z. 55(5):359-367.
Jensen, R. E., and L. W. Boyle. 1965. The effect of temperature, relative humidity and precipitation on peanut leafspot. Pl. Dis. Rep. 49 (12): 975-978.
Klisiewicz, J. M. 1965. Identity of viruses from safflower affected with necrosis. Pl. Dis. Rep. 49:541-545.
Klisiewicz, J. M. 1965. Utilization of carbon compounds by zoospores of Phytophthora drechsleri and their effect on motility and germination. Phytopath. 55:1257-1261.
Mixon, A. C. 1965. Influence of plant residues on the activities of Sclerotium rolfsii. Phytopath. (Abst.) 55(10):1069.
Rivers, G. W., J. A. Martin, and M. L. Kinman. 1965. Reaction of sesame to Fusarium wilt in South Carolina. Pl. Dis. Rep. 49:383-385.
Rivers, G. W., M. V. Meisch, and P. J. Hammon. 1965. Sesame: a new host for tobacco budworm and bollworm. Jour. Econ. Ent. 58:1003-1004.
Thomas, C. A., and G. C. Papavizas. 1965. Susceptibility of sesame and castorbean to Thielaviopsis basicola. Pl. Dis. Rep. 49:256.
Thomas, C. A. 1965. Effect of photoperiod and nitrogen on the reaction of sesame to Pseudomonas sesami and Xanthomonas sesami. Pl. Dis. Rep. 49: 119-120.

Thomas, C. A. 1965. Calcium and water-insoluble pectic compounds in safflower hypocotyls in relation to resistance to Phytophthora. (Abst.) Phytopath. 55:1079.

Zimmer, D. E. 1965. Rust infection and histological response of susceptible and resistant safflower. Phytopath. 55:296-301.

Zimmer, D. E. 1965. Efficacy of some antifungal substances for control of seedling safflower rust. Pl. Dis. Rep. 49:623-626.

Zimmer, D. E., and L. N. Leininger. 1965. Sources of rust resistance in safflower. Pl. Dis. Rep. 49:440-442.

van der Zwet, T. 1965. Basic studies on etiology and control of angular leaf spot of tung: primary infection by Mycosphaerella aleuritidis. (Abstr.) Phytopath. 55(5):502.

van der Zwet, T, and W. W. Kilby. 1965. Studies on etiology of Mycosphaerella aleuritidis in relation to control of angular leaf spot of tung (Aleurites fordii). Intern. Symp. on Crop Protec. Proc. 17, Vol. 3:1683-1697.

van der Zwet, T., B. G. Sitton, W. A. Lewis, and W. W. Kilby. 1966. Angular leaf spot of tung caused by Mycosphaerella aleuritidis: Effect of disease on yield and oil content of the fruit. Pl. Dis. Rep. 50(1): 54-58.

van der Zwet, T., B. G. Sitton, S. Merrill, Jr., and W. W. Kilby. 1965. Angular leaf spot of tung (Aleurites fordii). Miss. Agr. Exp. Sta. Bul. No. 705, pp. 23.

Varietal Evaluation

Culp, T. W., and W. R. Azlin. 1965. Sunflower tests in the Mississippi Delta. Miss. Farm Research 28:1-2.

Culp, T. W., and W. R. Azlin. 1965. Sesame seed yields in the Mississippi Delta. Miss. Farm Research 28:4.

Culp, T. W.,and M. L. Kinman. 1965. Rust on sunflowers in the Mississippi Delta. Pl. Dis. Rep. 49:433-434.

Kinman, M. L., and F. R. Earle. 1964. Agronomic performance and chemical composition of the seed of sunflower hybrids and introduced varieties. Crop Sci. 4:417-420.

Culture & Physiology

Culp, T. W., and W. R. Azlin. 1965. Early harvesting of castorbeans. 1965. Miss. Farm Research 28:4-5.

Culp, T. W., and C. G. McWhorter. 1965. CIPC and other herbicides for weed control in sesame. Weeds 13:367-370.

Culp, T. W.,and C. G. McWhorter. 1966. Amiben and diuron preemergence in castorbeans. Weeds 14:171-173.

Culp, T. W., and C. G. McWhorter. 1966. Tolerance of castorbeans to directed applications of herbicide naptha. Miss. Farm Research 29:5-6.

Dybing, C. D. 1965. Oil formation by embryo and endosperm tissues of maturing flaxseeds. Pl. Physiol. 40 (suppl.):xvii. (Abst.).

Dybing, C. D., and D. C. Zimmerman. 1965. Temperature effects on flax (Linum usitatissimum L.) growth, seed production, and oil quality in controlled environments. Crop Sci. 5:184-187.
Ford, J. H. 1965. Relation between seed weight and seeds per boll in flax. Crop Sci. 5:475-476.
Merrill, Samuel. 1965. Growing good nursery stock. Proc. 32nd Ann. Tung Industry Convention. pp. 31-33.
Peterson, Walter F. 1965. Safflower culture in the West-Central Plains. USDA Inf. Bul. No. 300.
Sitton, B. G. 1965. Nutritional problems of tung production. Proc. 32nd Ann. Tung Industry Convention, pp. 6-8.
Zimmerman, D. C., and H. J. Klosterman. 1965. Lipid metabolism in germinating flaxseed. J. Am. Oil Chem. Soc. 42:58.

PUBLICATIONS--STATE EXPERIMENT STATIONS

Cox, F. R., and P. H. Reid. 1965. Interaction of plant population factors and level of production on the yield and grade of peanuts. Agron. J. 57(5):455-457. (North Carolina)
Davidson, J., and D. M. Yermanos. 1965. Flowering pattern of flax (Linum usitatissimum L.). Crop Sci. 5(1):23-28. (California)
Smith, J. D., and M. L. Kinman. 1965. The use of parent-offspring regression as an estimator of heritability. Crop Sci. 5:595-596. (Texas)
Yermanos, D. M., and J. R. Goodling. 1965. Effect of temperatures during plant development on the fatty acid composition of linseed oil. Agron. J. 57(5):453-454. (California)
Diener, U. L., and F. E. Garrett. 1965. Toxin-producing ability of Aspergillus flavus strains grown on peanuts and on artificial medium. Proc. Assoc. S. Agr. Workers 62, p. 229. (Alabama)
Eldridge, D. W., N. D. Davis, U. L. Diener, and V. P. Agnihortri. 1965. Aflatoxin production by Aspergillus flavus in a chemically-defined liquid medium. Proc. Assoc. S. Agr. Workers. (Alabama)
Eldridge, D. W., N. D. Davis, and U. L. Diener. 1965. Aflatoxin content and fatty acid composition of peanuts inoculated with Aspergillus flavus. Phytopath. 55, p. 1057. (Alabama)
Diener, U. L., C. R. Jackson, W. E. Cooper, R. J. Stipes, and N. D. Davis. 1965. Invasion of peanut pods in the soil by Aspergillus flavus. Pl. Dis. Reptr. 49:931-935. (Alabama)
Diener, U. L., C. R. Jackson, W. E. Cooper, R. J. Stipes, and N. D. Davis. 1965. Invasion of peanut pods in the soil by Aspergillus flavus. Pl. Dis. Reptr. 49(11):931-935. (North Carolina)
Ashworth, L. J., Jr., H. W. Schroeder, and B. C. Langley. 1965. Aflatoxins: Environmental factors governing occurrence in Spanish peanuts. Sci. 148:1228-1229. (Texas)

WEED AND NEMATODE CONTROL
Crops Research Division, ARS

Problem. Weeds cause losses in crops, orchards, grazing lands, forests, water supplies, and irrigation and drainage systems. The losses caused by weeds can be reduced by finding more effective chemical, biological, mechanical, cultural and combination methods of weed control. Improved weed control methods will facilitate farm mechanization, increase production efficiency, and improve the efficiency of the use of human and land resources in agriculture.

Plant-parasitic nematodes occur in all soils used for growing of crop plants and attack all kinds of plants grown for food, forage, fiber, feed, or ornamental purposes. It has been long known that severity of attack by certain fungi is greatly increased if nematodes are present; and nematodes have been known to be the vectors of several plant viruses. There is a need for improvements in the methods of controlling nematodes by crop rotations, cultural practices, chemicals, and biological methods on oilseeds and peanuts.

USDA AND COOPERATIVE PROGRAM

Much of the weed control research in the Department is cooperative with State Experiment Stations, other Federal agencies, industry and certain private groups, and is cross commodity in nature. The total Federal scientific effort devoted to weed control involves 82.0 professional man-years effort. Of this total 6.5 is specifically directed to weed control in oilseeds and peanuts.

The Department has a long-term continuing program of basic and applied research on various phases of nematology which contribute information of value to nematode control. In the past few years, as State nematology programs have developed there has been increased emphasis on basic research by the Department. Basic research on nematode taxonomy and physiology is located in Beltsville, Maryland, while 13 field stations combine applied and basic research in varying proportions. Besearch on nematodes affecting oilseeds and peanuts is conducted at Auburn, Alabama; Tifton, Georgia; Urbana, Illinois; Beltsville, Maryland; and Jackson, Tennessee.

The Federal scientific effort devoted to research in this area in F.Y. 1966 totaled 29.3 man-years. Of this, 14.2 were devoted to basic research on nematodes and 2.3 to oilseeds and peanuts.

PROGRAM OF STATE EXPERIMENT STATIONS

State experiment stations are conducting basic and applied research in weed control. These studies involve evaluation of selective herbicidal properties of new chemicals to show the relation between chemical plants and soils.

Nematology research programs are actively pursued in 47 States and Puerto Rico. Collectively, this well-organized research program is supported not only by the institutions involved but also by such agencies as the National Science Foundation, National Institutes of Health, private institutes, foundations, and industry. Fundamental investigations in nematology continue to receive major emphasis by State scientists.

PROGRESS - USDA AND COOPERATIVE PROGRAMS

I. Weed Control

a. Soybeans

Herbicide Injection. Vernolate injected as a liquid in parallel lines three inches apart and 1-1/2 inches deep in the soil before planting soybeans produced excellent preemergence weed control without significant crop injury.

Species controlled included morning-glory, cocklebur, sesbania, and Johnsongrass from rhizomes, and many species of annual grasses. This appears to be the most effective preemergence treatment evaluated to date in soybeans because of the wide spectrum of weeds which is controlled and the minimization of adverse environmental conditions on herbicide performance.

New Methods of Herbicide Application. Two new methods of herbicide application were developed in Mississippi during 1965. In one, a sprayer directs herbicide sprays at right angles to and above the crop plants into a recovery device which returns the portion of the herbicide spray not applied to weeds to the original spray tank. The spray passes over the top of the crop plants and contacts only weeds growing several inches above the crop. This type of treatment is especially useful in controlling infestations of certain weeds such as cocklebur and sesbania and possibly Johnsongrass. Since a relatively low amount of the herbicide contacts the crop plants, use of this spray system may permit the use of herbicides normally considered too toxic for use in several crops. This method of application practically eliminates contact of herbicides with the soil and greatly reduces toxicity problems for subsequent crops. The other method of application involves a device which converts herbicide spray solutions containing a surfactant into a relatively thick foam. The foam can be directed to the soil surface in preemergence applications or it can be

applied as a basally directed postemergence application in growing crops. The herbicide-containing foam has the ability to creep around, over and behind obstacles such as sticks and clods in the row, and has a relatively low drift hazard.

Soybean-weed Competition. In soybean-weed competition research in Illinois, if weeds were not controlled in the soybean row, soybean yields were reduced more than 80%. However, if the soybean rows were kept free of weeds for 4 to 6 weeks after planting, yields were as high as in plots which were kept weed free all season. Very little growth of either broadleaf or grass weeds occurred in the soybean row after soybeans were kept weed free for 4 weeks following planting. Where soybeans were removed immediately after emergence, only a small amount of grass weeds emerged and developed if the plots were kept weed free for 6 weeks following planting. Under these conditions, almost no broadleaf weeds emerged and developed if plots were kept weed free for 10 weeks following planting. The implications of these results and studies at other locations indicate that we need to evaluate the possibility of accepting less than 100 percent full season weed control in many crops because of herbicide residues, and ecological and economic considerations.

Herbicide Performance. In Georgia, trifluralin and vernolate severely reduced the height and stands of soybeans, but did not reduce yield significantly when incorporated in the soil before planting. Timing or preemergence herbicide mixtures in relation to soybean tolerance appears to be critical on some soils, particularly when excess rain immediately precedes or follows planting. A delay in the application of herbicides for two days after planting substantially improved tolerance of soybeans to preemergence mixtures of NPA and PCP or amiben and DNBP.

In Mississippi, trifluralin, CP 31393, amiben, and linuron gave effective preemergence weed control in soybeans although each of these herbicides was not effective in controlling certain broadleaf weeds and Johnsongrass from rhizones. Postemergence applications of diuron gave effective and economical weed control in soybeans if excessive drought or rainfall did not prevent timely application. Trifluralin did not injure soybeans if incorporated to a depth of 1 inch, but caused severe injury if incorporated 2 inches deep.

In Illinois, effectiveness of preplanting soil incorporation and preemergence herbicide treatments varied considerably with location, rainfall, and species. In general, control of annual grasses was better than control of annual broadleaf weeds such as velvetleaf, and annual morning-glory. The effectiveness of trifluralin and SD 11831 was increased by incorporation as compared to surface application. Incorporation by disking reduced the effectiveness of most other herbicides. Trifluralin is an excellent herbicide for the control of many grass weeds from seed and some broadleaf weed species. However, the broadleaf weed species spiny sida, velvetleaf, annual morning-glory, and Venice mallow appear tolerant to trifluralin at normal rates of application. Preemergence amiben, CP 31393, and trifluralin were the outstanding herbicides for soybean weed control in Illinois. Most of the outstanding herbicide combinations included amiben.

b. Peanuts

Injection of Herbicides. Injection involves placement of the herbicide beneath the soil surface in parallel lines at depths of one to several inches. The injection is made by passing the liquid through a tube on the back of a small knife which is pulled through the soil by tractor equipment. Two to many knives may be used on any one machine depending upon the pattern of treatment desired. EPTC, pebulate, and vernolate, applied as subsurface line injection treatments before or at planting time, gave effective control of nutsedge and annual weeds in peanuts. The substitution of line injection of these herbicides for subsurface placement in bands appeared to provide equally effective weed control and increased crop tolerance.

Subsurface Placement of Herbicides. Subsurface placement of thiolcarbamate herbicides, and depth of application, appeared to critically affect herbicial activity. Placement in a swath 5-1/2 inches below the soil surface was less effective than placement at 1-1/2 inches. The relative toxicity of pebulate appears to be increased more by subsurface application than that of either EPTC or vernolate.

DMPA-DNBP Mixture. For the fourth consecutive year, a mixture of DMPA at 6 lb/A plus DNBP at 3 lb/A applied during the emerging stage of peanuts significantly increased yields. The fundamental basis for this yield increase is not known, but is suspected to be connected with inhibitory effects of the treatment upon soilborne diseases.

II. Nematode Control

Peanuts. *Aspergillus flavus* was higher in Georgia peanuts infected with root-knot nematodes than in non-nematode infected peanuts. However, *A. flavus* in peanuts was not increased by root-lesion nematodes. Moderate resistance to the peanut and northern root-knot nematodes was found in several peanut varieties and breeding lines: entries having low root-knot gradings for *M. hapla* also had low indices for *M. arenaria*. Best nematode resistance occurred in Dixie Giant C and PI-221068, followed by Va. 61R and Florigiant. The most susceptible varieties were Tennessee Red, Early Runner, Virginia Bunch, Starr, and Argentine Spanish. Field plot studies indicate that Virginia Bunch 67 is more resistant to root-lesion nematodes than Georgia 186-28, Early Runner, Argentine, Starr, or Florigiant. Starr and Argentine were more resistant to ring-nematodes than the Virginia Bunch 67, Early Runner, Georgia 186-28, and Florigiant. All varieties were resistant to Georgia populations of sting nematodes.

Soybeans. Extensive damage from root-knot and sting nematodes was observed on root-knot resistant 'Jackson' and 'Hampton' soybeans in South Carolina where soybeans are grown in rotation with vegetables and melons. Examination of soybeans in 152 fields in northwest Florida, Alabama, and Georgia revealed that large numbers of nematodes, representing 11 genera, caused significant damage to soybeans. The nematodes causing

the greatest damage were root-knot, spiral, root-lesion, sting, and reniform nematodes. Frequently, root-knot resistant varieties were badly damaged by southern root-knot nematodes, reniform, and root-lesion nematodes. Greenhouse studies indicate that the reniform nematode, heretofore an unknown parasite of soybeans, reduced growth of 'Brag', 'Hardy', 'Hood', 'Jackson', and 'Lee' soybeans by 40 percent. Unless control measures are developed, nematodes will limit the production of soybeans on the Gulf and Atlantic Coastal Plains. Studies on the soybean-cyst nematode at Jackson, Tennessee, showed that the resistant soybeans 'Pickett' and 'D63-7320' produced 50 percent higher yields than non-resistant varieties. In addition to soybean-cyst nematode resistance, the advanced breeding line D63-7320 has good resistance to two species of root-knot nematodes and can be grown as far north as southern Illinois. 'Illsoy', which is moderately resistant to the soybean-cyst nematode does not permit an appreciable increase of cyst nematodes. Morphological studies of soybean-cyst nematodes from Holland, Virginia, developed on nematode resistant and susceptible lines, indicating that the Holland population is different from the Wilmington, North Carolina, population. However, the nematodes from Wilmington are the only ones found in the Eastern United States that cause severe chlorosis and stunting of soybeans. Soybean-cyst nematodes from other areas differ morphologically and physiologically from the above two populations. These studies indicate there are two, and possibly three, biological races of the soybean-cyst nematode which have differing characteristics with regard to plant resistance, nematode morphology, and pathogenicity. No resistance has been found in soybean varieties and breeding lines to the northern root-knot nematode; however, studies in Tennessee showed that Delmar and No. 29 (from D63-7320) had good resistance to the cotton and southern root-knot nematodes, while NC 55, Missouri, Lee, Pinedell, and Pickett, were highly susceptible to all root-knot species.

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Weed Control in Oilseed Crops

Culp, T. W. and C. G. McWhorter. 1965. CIPC and other herbicides for weed control in sesame. Weeds 13:367-369.

Hauser, E. W. and S. A. Parham. 1965. Progress report: subsurface application of thiocarbamate herbicides for weed control in peanuts. Southern Weed Conf. Proc. 18:115-116.

Hauser, E. W. and W. H. Merchant. 1965. Progress report: weed control in soybeans, 1965. Southern Weed Conf. Proc. 19:119-120.

Hauser, E. W. 1965. Preemergence activity of three thiocarbamate herbicides in relation to depth of placement in the soil. Weeds 13:255-257.

Hauser, E. W. and W. H. Merchant. 1965. Progress report: weed control in soybeans in the Coastal Plain. Southern Weed Conf. Proc. 18:45-46.

McWhorter, C. G. and E. E. Hartwig. 1965. Effectiveness of preplanting tillage in relation to herbicides in controlling Johnsongrass for soybean production. Agron. Jour. 57:385-389.

Oilseeds and Peanuts

Epps, J. M., and A. Y. Chambers. 1965. Nature of resistance in soybean varieties to Heterodera glycines. Phytopath. 55: 498-500.

Good, J. M., and J. R. Stansell. 1965. Effect of irrigation, soil fumigation, and date of harvest on Pratylenchus brachyurus (Godfrey) Filipjev & Schuurmans Stekhovan, infection of pegs, peg rot, and yields of peanuts. Nematologica 11: 38-39.

Nematodes in Oilseeds and Peanuts

Epps, J. M., and Albert Y. Chambers. 1964. Nematocidal seed treatment for control of Heterodera glycines in soybeans. Phytopath. 54: 622.

Epps, J. M. and Albert Y. Chambers. 1964. Behavior of populations of Heterodera glycines under various cropping sequences in field bins. Phytopath. 54: 622.

Epps, James M., J. N. Sasser, and Grover Uzzell, Jr. 1964. Lethal dosage concentrations of nematocides for the soybean-cyst nematode and the effect of a nonhost crop in reducing the population. Phytopath. 54: 1265-1268.

Good, J. M., and J. R. Stansell. 1964. Effect of irrigation, soil fumigation, and date of peanut harvest on Pratylenchus brachyurus (Godfrey) infection of pegs, peg rot, and yield of peanuts. Nematologica 11: 38-39.

PUBLICATIONS -- STATE EXPERIMENT STATIONS

Bovey, R. W. and O. C. Burnside. 1965. Aerial and ground applications of preemergence herbicides in corn, sorghum, and soybeans. Weeds 13:334-336. (Nebr.)

Chambers, A. Y., and Epps, J. M. 1965. Comparative susceptibility of hosts for reproduction of the soybean-cyst nematode. Phytopathology. 55:497. (abstract) (Tenn.)

Davis, D. E., J. V. Gramlich, and H. H. Funderburk, Jr. 1965. Atrazine absorption and degradation by corn, cotton, and soybeans. Weeds 13:252-255. (Ala.)

Knake, E. L., F. W. Slife, and R. D. Seif. 1965. Flame cultivation for corn and soybeans. Weeds 13:52-56. (Ill.)

Swan, D. G. and F. W. Slife. 1965. The absorption, translocation, and fate of amiben in soybeans. Weeds 13:133-138. (Ill.)

SOYBEAN AND PEANUT INSECTS
Entomology Research Division, ARS

Problem. Soybeans and peanuts are severely damaged by several insect pests in the different areas where these crops are grown in the United States. The increasing concentration of acreage in soybeans and possibly the adaptation of native insects to this crop are resulting in more varied and more serious insect problems. Basic information is lacking on the biology of many of these pests and on the extent and nature of damage they cause to these crops. Such information is needed to serve as a foundation for the development of satisfactory control methods. Some insecticides, although highly effective in controlling insects on soybeans and peanuts, cannot be used because they leave harmful residues. Further, certain insects have developed resistance to insecticides that are currently recommended. For the immediate future, there should be continued effort to find insecticides that can be used safely and that give effective, economical control of all species of insects attacking these crops. For more desirable long-range solutions to the problems, more attention needs to be given to nonchemical control methods, with particular emphasis on insect-resistant crop varieties and biological control agents and the exploration of new chemical approaches such as attractants and repellents.

USDA AND COOPERATIVE PROGRAM

The Department has a limited program involving basic and applied research on insect problems of peanuts and soybeans directed toward developing efficient and economical control methods. The program is cooperative with State and Federal entomologists, agronomists, and chemists. Studies on soybean insects are conducted at Columbia, Mo., and on soybean and peanut insects at Tifton, Ga., in cooperation with the Missouri and Georgia Experiment Stations

A grant to the Oklahoma Experiment Station will provide information on varietal resistance of peanuts to thrips.

The Federal scientific effort devoted to research in this area totals 2.5 scientist man-years. Of this number 0.5 man-year is devoted to basic biology; 0.3 to insecticidal control; and 0.1 to biological control; 1.4 to varietal evaluation for insect resistance; 0.1 to insect vectors of diseases; and 0.1 to program leadership.

In addition, Federal support of research in this area conducted under grants provides a total of 0.4 scientist man-year on varietal resistance.

PROGRAM OF STATE EXPERIMENT STATIONS

A total of 7.4 professional man-years is devoted to this area of research.

PROGRESS -- USDA AND COOPERATIVE PROGRAM

A. Basic Biology, Physiology, and Nutrition

1. Soybean Insects. Studies at Columbia, Mo., indicated that, based on larval weight and rate of larval development, soybeans was a less desirable host for the corn earworm than cotton or tomatoes. First instar larvae of Heliothis zea were transferred to tomatoes, cotton, and soybeans grown in the greenhouse. Larval weights were recorded at intervals to determine differences in development on different hosts. Results indicated that larval weight was increased and pupation occurred earlier where larvae were reared on tomatoes. Lesser weights and later pupation occurred when the larvae developed on cotton and soybeans in that order.

At Columbia, Mo., the broadheaded bug, Coriscus pilosulus, has been reared continuously in the laboratory. A summary of the life history of this vector of yeast spot disease of soybeans is as follows: Egg incubation period 8 days, period from hatch to adulthood 27 days, preoviposition period 6.5 days, adult longevity 23.6 days. The egg viability averaged 76.8%. The percent mortality which occurred in each of the instars was: first, 4.9%; second, 15.4%; third, 21.6%; fourth, 23.4%; and fifth, 19.75%. Adult longevity was 23.6 days. The sex ratio of 89 adults was 40.45% males and 59.55% females.

2. Peanut Insects. Observations at Tifton, Ga., on the activities of the lesser cornstalk borer on peanuts indicated that larvae upon hatching, either fed on flower axils and entunneled in webbing or fed on leaves at the base of the plant and entunneled in combined webbing and soil. Feeding in flower axils continued only until the larvae reached the third or fourth instar, when they abandoned this location and migrated to the soil level to begin feeding. No plants were killed due to the lesser cornstalk borer and larvae were not found within the pods. It appears that the larva may be largely a defoliator, especially of basal leaves of peanut plants.

B. Insecticidal Control

1. Fall Armyworm. At Tifton, Ga., 6 insecticides were field-screened on soybean foliage at 4, 8, and 16 ounces per acre to determine their toxicity to 4-day-old fall armyworm larvae. The insecticide Schering 34615 gave 88% control at 16 ounces per acre and the 4-and 8-ounce rates gave good control through the fourth day. General Chemicals GC-6506 gave good control, one day after treatment, but poor control on the fourth day. The insecticide Geigy GS-13005 at 16 ounces per acre was effective through one day, but gave only fair control on the second day. Niagara NIA-10242 gave excellent control through the second day at 8 and 16 ounces per acre, but only through the first day at 4 ounces per acre.

2. Thrips. At Columbia, Mo., Azodrin at 0.6 pounds per acre gave excellent control of thrips on soybeans. A mixture of DDT (1.5 lb) and parathion (0.25 lb) gave good initial control, but was not effective after 6 days.

C. Varietal Evaluation for Insect Resistance

1. Soybean Insects. At Columbia, Mo., over 525 soybean varieties, principally plant introductions, were evaluated for resistance to the green stink bug Acrosternum hilare in a large field cage measuring 100' long 60' wide and 8' high. Differential damage between varieties has been recorded but no highly resistant varieties have been found.

2. Peanut Insects. At Tifton, Ga., advanced peanut lines were evaluated for resistance to an artificial infestation of the lesser cornstalk borer and natural infestations of the velvet bean caterpillar, the fall armyworm, the corn earworm, and thrips. Four varieties (Runner check, Ga. 186-38, Florida 416, and Florigiant) were significantly low in foliar ragging. A significant association existed between levels of foliar ragging and yield among lines. Five varieties (NC-2, Argentine, V.B. 67, Starr, G.E. 652) showed some resistance to thrips.

A grant was recently awarded to the Oklahoma Experiment Station to evaluate peanut varieties for resistance to thrips.

D. Insect Vectors of Diseases

1. Soybean Insects. The organism, Nematospora coryli, has been shown to be harbored within the salivary system of the green stink bug. Isolations of this organism have been made repeatedly from sterilely dissected salivary receptacles and salivary pump of the insect. The salivary receptacles and stylets of this insect were found to harbor the yeast 35 and 55% of the time, respectively. The insects had a higher frequency of occurrence of the organism as the season progressed from July to September. Heretofore it was believed that the disease was transmitted only incidentally and by external contamination of the insect.

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAM

Basic Biology, Physiology and Nutrition

Leuck, D. B. and R. O. Hammons. 1965. Pollen-collecting activities of bees among peanut flowers. J. Econ. Entomol. 58: 1028-30.

Biological Control

Leuck, D. B. and Minter Dupree. 1965. Parasites of the lesser cornstalk borer. J. Econ. Entomol. 58: 779-80.

Insecticide Residue Determinations

Beck, E. W., L. H. Dawsey, D. W. Woodham, and D. B. Leuck. 1966. Dimethoate residues on soybeans, corn, and grass forage. J. Econ. Entomol. 59: 78-82.

TILLAGE, PEST CONTROL TECHNIQUES AND EQUIPMENT; HARVESTING AND HANDLING OPERATIONS; CROP PREPARATION AND FARM PROCESSING; AND USE OF ELECTROMAGNETIC AND ULTRASONIC ENERGY

Agricultural Engineering Research Division, ARS

Problem. Tillage of the soil is the greatest consumer of power in the production of crops in the United States today While some tillage is needed for nearly all crops, there is good evidence that much unneeded and in some cases detrimental tillage operations are performed. There is a need for expanded research to give more precise information on the interrelationship of tillage, soil physical conditions, and plant growth.

Many pests attack oilseeds and peanuts resulting in dollar losses to farmers each year. Plant diseases, weeds, insects and nematodes are examples Every method to control or eradicate any of these pests requires some type of equipment, be it a small chemical sprayer or a giant bulldozer. There is a need for improved methods of much greater efficiency for applying pesticides to plants and the soil.

Development of equipment and methods for efficiently harvesting and farm handling oilseeds and peanuts, with emphasis on the preservation of inherent qualities during these processes is needed. The cost of harvesting and farm handling of most crops is the major expense of production, often amounting to over half of the total returns to the producer from the sale of the product. In addition, supply and adequacy of manpower for these operations are becoming progressively less satisfactory. While research on harvesting equipment and methods has led to much improvement in the reduction of production costs of some crops, much additional work needs to be undertaken, both basic and developmental, in order that all crops may be mechanically handled.

Development of better methods, techniques, and equipment for use on farms for the initial preparation for market or the processing of oilseeds and peanuts is needed to increase efficiency in the use of labor and equipment, preserve quality and prevent spoilage and damage from mechanical handling. While considerable information has already been obtained for the development of processes such as drying and separation, basic and more precise information must be developed for these and other processes before development progress can be continued. The underlying principles that pertain to the cleaning and drying of different crops, curing of peanuts, and sorting need to be determined. The methods for processing farm crops are largely dependent on production practices and dictated by future handling or storage requirements. Consequently, this requires interdisciplinary collaboration in the creating of a completely mechanized program of crop production.

Production of many crops is hampered by poor, slow, or nonuniform emergence of seedlings after the seed is planted. Some electrical treatments have been found to accelerate germination and seedling emergence. If emergence in the field can be speeded up and better uniformity obtained, weed control can be much more effective, with resulting increased efficiency in production of crops.

USDA AND COOPERATIVE PROGRAM

The Department has a continuing long-term program involving agricultural engineers and soil scientists engaged in both basic studies and the application of known principles to solve problems dealing with the relationships between soil-engaging equipment and soil reactions. Also, a program in pest control techniques and equipment includes weed control in soybeans involving about 1.0 professional man-year.

A continuing long-term program is conducted involving agricultural engineers engaged in both basic and applied research on the engineering phases of crop harvesting and handling. Research on oilseeds and peanut harvesting equipment and methods is cooperative with the experiment stations at Bogalusa, Louisiana (tung nut); Holland, Virginia (peanuts); and Tifton, Georgia (peanuts). Contracts have also been initiated at Virginia Polytechnic Institute for study of equipment and methods for farm curing and drying of Virginia-type peanuts and at the Georgia Coastal Plain Experiment Station for determination of location, nature and extent of losses and damage occurring in peanut harvesting and farm handling. The Federal engineering effort devoted to research on oilseeds and peanuts harvesting and handling operations and equipment totals 5.5 professional man-years.

The Department's effort in the area of crop preparation and farm processing (except cotton) constitutes a long-term program involving agricultural engineers and statisticians engaged in both basic and applied research on the engineering phases of crop preparation and farm processing. Research on the processing on tung nuts is conducted at Bogalusa, Louisiana, in cooperation with the Mississippi Experiment Station and industry. The Federal engineering effort devoted to research in this area totals 0.6 professional man-years.

Studies on effects of electric glow-discharge radiation on seeds and plant products have been continued at Knoxville, Tennessee.

PROGRAM OF STATE EXPERIMENT STATIONS

Many of the State agricultural experiment stations are engaged in both fundamental and applied research dealing with the development of new principles and the application of currently available knowledge to the problems concerned in soil-machine relationships in order to increase efficiency in crop production.

Both basic and applied research investigations which have been designed to discover and develop methods, techniques, and equipment for control of the many pests that attack our economic crops are in progress at the several agricultural experiment stations. Much of this work is cooperative with the Department.

These studies are involved in the complicated objectives of furthering the efficiency and the means for better control of insects, plant diseases, nematodes and weed problems through application of engineering knowledge on the use of aerial and ground chemical applicators for liquids and dusts, flame cultivators and mechanical devices for soil manipulation and soil fumigation.

Detailed investigations are in progress to develop reliable mechanical harvesting and handling equipment as well as ways in which improvements might be made in crop production systems to increase yields, product quality and overall efficiency.

Drying or curing investigations are in progress on forage crops, cereal crops including rice, feed grains including grain sorghums and soybeans, nuts, tobacco, peanuts and coffee. Closely associated with these studies are development and adaptation studies of flow systems, equipment and packages to move products without damage into and out of storages and to the market place.

Investigations in progress many of which are cooperative with the Department involve the evaluation of the use of radiofrequency energy for treatment of grains to destroy insect infestation and treatment of seeds to improve their germination characteristics.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Weed Control in Soybeans

Field studies were continued to determine the effectiveness of 8-, 10-, 12-, 14-, and 16 inch band applications of amiben (two pounds per acre) and Na-PC (sodium salt, 20 pounds per acre) for weed control in soybeans. The narrow band widths had a greater number of weeds though not enough to reduce the soybean yields. Very little lateral movement of the herbicide was observed for any of the band widths.

Studies on weed control equipment and practices for narrow-row corn and soybean production, in cooperation with the Iowa station, indicate that the equipment and systems now used for conventional row spacing will give satisfactory weed control. These studies indicate a need for changing the cultivator sweep spacings for mechanical control and for changing the nozzle and granular spreading device spacings for chemical control. Earlier soil shading with the narrow rows resulted in over-all improved weed control at the end of the season.

Studies were continued on the evaluation of smoothing operations after planting and shallow cultivations with high-speed tools. Smoothing operations evaluated were spike-tooth harrowing after planting, strip smoothing with a dragging hoe after planting, and no smoothing after planting. Early shallow cultivation practices included rotary hoeing, strip tillage over the row with a dragging hoe, and no early cultivation. Although the stand reduction was not exactly reflected in yields, smoothing operation directly following planting tended to reduce stands. The stand reduction was highly significant where the strip dragging hoe was used. Harrowing after planting did result in slightly better weed control. Using the rotary hoe or dragging hoe early and following this with one cultivation gave better weed control than two cultivations alone. Additional operations with the shallow cultivating tools did not improve the weed control obtained and tended to further reduce stands. This was particularly true where the dragging hoe was used. The results of this test indicate an increase in effectiveness of shallow cultivating tools if corn land is smoothed with a tool such as a drag harrow directly following planting. Timeliness of cultivation and proper adjustment of cultivator tools appear to be more effective for controlling weeds in corn than the selection of a particular practice or cultivating tool.

In conjunction with some of the tillage field plot studies, in Iowa, early spring herbicide applications were evaluated. Atrazine, simazine, and 2,4-D sprays were applied on sod ground in early April. With the triazine compounds it was possible to obtain satisfactory weed control with only one mechanical cultivation. With the 2,4-D sprays, it was necessary to perform the normal mechanical cultivation series in order to control weeds. During the past several years, these early spring applications of atrazine and simazine have given more consistent results in terms of weed control than any other type or time of application.

2. Field studies were continued, in cooperation with the Missouri station, to compare the effectiveness of four methods of shallow (above the seed) incorporation of amiben (one and two pounds per acre) and trifluralin (one pound per acre) for weed control in soybeans. The rotary hoe, Atkins-Phelps Mix-A-Product, power rotary cultivator, and Gandy Ro-Wheel were used to incorporate the herbicides after the soybeans were planted. Amiben applied at two pounds per acre and trifluralin applied at one pound per acre

gave much better weed control than amiben applied at one pound per acre. In most of the treatments, incorporation did not increase weed control; and in some of the treatments, weed population was increased over nonincorporated treatments. These results show that there is no particular advantage of incorporation with this equipment and for these herbicides.

Field studies were initiated, in cooperation with the Missouri station, to further study methods and equipment for incorporation of herbicides prior to planting soybeans. The power rotary cultivator, Atkins-Phelps Mix-A-Product, and the disk harrow were used to incorporate trifluralin (one pound per acre) and amiben (one and two pounds per acre) in field plots in Mexico silt loam soil. All incorporation was done at an operating depth of four inches. The herbicides were applied just ahead of the incorporation equipment. Some differences in results were obtained due to the herbicide that was used but not because of the incorporation treatment. The soybean yields were the same for all incorporation treatments and for those plots that did not receive the incorporation treatments. Early field notes indicated that the incorporation increased the effectiveness of the trifluralin more than it did for the amiben.

Laboratory studies were initiated in Missouri to study the possible use of ultra low volume (.1 to 5 GPA) preemergence applications of herbicides for weed control in row crops. Initial work this year has been done to study the relationship between droplet size distribution, area covered, and volume distribution of small fan and industrial atomizing nozzles. Droplet size distribution and area data were obtained by photographing droplets collected on Scotchprint paper and Lusterkote cards. The photograph negatives were analyzed on a flying-spot particle analyzer. Volume distribution data was obtained by using a fluorescent, dye tracer method of analysis. The data will be analyzed during the next year to determine some of the characteristic spray patterns that can be obtained when using these nozzles for low volume application.

Chemicals used in Iowa to study soil incorporation of preemergence herbicides for weed control in soybeans included Treflan liquid, Treflan granules, Ramrod granules, amiben liquids, and amiben granules. These compounds were applied at recommended rates, and soil incorporation treatments included power rotary strip tillage before planting, disking and harrowing before planting, harrowing after planting, and no incorporation. All chemically treated plots received one mechanical cultivation. The untreated check plots were rotary hoed and cultivated once. All chemicals gave good early weed control. However, timely rotary hoeing gave equal or superior weed control to that received with the chemicals. Soil incorporation with a spike-tooth harrow after planting resulted in slightly better weed control than soil incorporation before planting. Surviving weeds as indicated by weed weights obtained in August, and soybean yield data showed that the weed control and yields were not materially improved where chemicals were used.

B. Oilseeds and Peanut Harvesting Equipment

1. Studies of pruning and training tung trees to facilitate mechanical harvesting showed that 3-year-old trees trained to a 5-1/2-foot height had significantly less total linear growth than untrained trees. However, there was not significant difference in yield of fruit. Neither was there a significant difference in yield when older trees pruned to a height of 5-1/2 feet were compared to unpruned trees of the same age.

2. Simplified design of a mechanical tung nut harvester resulted from blowing air through the nuts as they moved up the slotted rubber belt from the pick-up brush. This removes about 40 to 50 percent of the leaves and eliminates the need for an inclined rotating drum which was originally designed for this purpose.

3. Peanut digger development. An experimental peanut digger equipped with an elliptical wheel dirt-removing assembly, was tested in Georgia and Virginia. Under Georgia conditions, the digger choked repeatedly with soil and vines, and excessive wrapping of vines occurred on the dirt-removing assembly. These tests showed that design modifications must be made if the digger can be used under these conditions. A commercial digger, used to dig Virginia-type peanuts in Georgia, left an average of 2,815 pounds of soil per acre mixed in the vines and 646 pounds of peanuts per acre in the soil (13 percent of the yield), indicating that improvements need to be made. Under Virginia conditions, the experimental digger performed more satisfactorily. Used when the soil moisture content averaged about 9 percent, the experimental digger left only 3,240 pounds of soil per acre mixed in the vines, compared to 23,510 pounds per acre left by the commercial diggers. With soil moisture content in the 13-15 percent range, the experimental digger left 8,210 pounds of soil per acre in the vines, whereas the average left by three commercial diggers was 25,180 pounds per acre.

4. Studies to determine the nature and extent of losses involved in harvesting peanuts showed that, under Georgia conditions, delaying harvest past normal maturity date greatly increases digging losses of Virginia-type peanuts. Spanish and Runner-type losses also increased as normal maturity was passed; however, the increase was not as large as with the Virginia-type. Next year, radioactive isotope tracers will be used to determine whether the peanuts were shed prior to digging or lost in the digging operations. This information should indicate whether a redesign of the digger would be beneficial.

5. A cleaner, consisting essentially of a hopper and two vibrating slotted screens, was used in studies on the separation of immatures and foreign material from peanuts. The cleaner removed from 84 to 96 percent of the immatures and from 55 to 62 percent of the foreign material; however, it also removed from 85 to 95 percent of the loose-shelled kernels. Larger

percentages of all fractions were removed from semi-cured than from green-harvested peanuts. Additional work needs to be done to increase the efficiency in removing immatures and foreign material and reduce the loose-shelled kernel losses.

Preliminary investigations were made to evaluate shell damage caused by mechanical manipulation in combine harvesting of peanuts. These tests were conducted by harvesting freshly-dug peanuts and peanuts that had been in the windrow for 8 days. These tests showed that 28.6 percent of the green-harvested peanuts had shells damaged in combing. Of this total, 1.6 percent were damaged by the stemming saws and 2.6 percent were damaged by the air lift elevator. When peanuts were left in the windrow for 8 days, these two components were responsible for over half of the damage. With these peanuts, 12.1 percent had hulls damaged by the stemming saws, 6.7 percent were damaged by the air lift elevator, and the total combing operation damaged 33.6 percent of the hulls. Since damaged hulls are considered to be conducive to the production of A. flavus, this work will be expanded.

C. Tung Nut Processing

1. Studies of hulling of tung nuts on the farm show that commercially available walnut hullers can be used for this purpose. One such machine was tested and found to have a capacity of 3 tons per hour. Losses of oil-bearing material ranged from 6 percent in fruit with 30 to 40 percent moisture to 9 percent when the fruit contained 20 to 30 percent moisture. By hulling on the farm, transportation costs will be lower and the guaranteed oil recovery percentage will be higher.

2. Studies on farm conditioning and storage of tung nuts were not conducted in 1965, because the crop was extremely light and dry and harvesting was completed by December 1.

D. Peanut Curing

1. Equipment was constructed to determine the feasibility of rapid drying of peanuts to reduce the potential for aflatoxin development. This unit allows precise control of airflow rate, temperature and humidity. Preliminary tests indicate that, by alternately passing hot and cool air through the peanuts, the drying rate may be increased without reducing quality. More extensive tests are planned.

2. Combine-run and recleaned peanuts were compared for airflow resistance and drying rate, using both green-harvested peanuts and peanuts which had been partially cured in the windrow. In the test boxes which were 1-foot cubes, there was not any statistical difference between combine-run and recleaned peanuts in either airflow resistance or drying rate. Since some loss of loose-shelled kernels occurs, recleaning combine-run peanuts does not appear profitable. Since the foreign material may tend to accumulate in large bins, areas of poor drying may occur, leading to the possibility of A. flavus production.

E. Effects of Electric Glow-Discharge Radiation

Field tests in cooperation with the Department of Agronomy, University of Tennessee, to determine whether glow-discharge treatments of soybeans might improve development, revealed no increase in yield as a result of glow-discharge treatments. Work on investigations of effects of glow-discharge treatment on soybean oil, which are cooperative with the Department of Food Technology, University of Tennessee, were temporarily interrupted because of transfer of AE personnel. This work is again underway and will be continued in 1966.

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Oilseeds and Peanut Harvesting Equipment

Butler, J. L. 1965. Harvesting and Farm Curing Peanuts. Peanut Farmer. August.

Duke, G. B. 1966. A Preliminary Report on Peanut Digger Performance. Proceedings of Southern Association of Agricultural Workers. Jackson, Mississippi. February.

Weed Control in Soybeans

Peters, E. J., Gebhardt, M. R., and Stritzke, J. F. 1965. Interrelations of Row Spacings, Cultivations and Herbicides for Weed Control in Soybeans. Weeds 13(4), pp. 285-289. October.

PUBLICATIONS -- STATE EXPERIMENT STATIONS

Tung Nut Processing

Dexter, S. T. 1965. A Convenient Gas-Constant for Use in Storage and Respiration Studies: The "Pound-Molecular Volume." Transactions of ASAE, Vol. 8, No. 2.

Eakker-Arkema, F. W., and Hall, C. W. 1965. Importance of Boundary Conditions in Solving the Diffusion Equation for Drying Forage Wafers. Transactions of ASAE, Vol. 8, No. 3.

II. NUTRITION, CONSUMER AND INDUSTRIAL USE RESEARCH

FLAX UTILIZATION - INDUSTRIAL PRODUCTS
Northern Utilization Research and Development Division, ARS

Problem. Traditional markets for linseed oil, the major drying oil produced and used in the United States, are threatened by widespread use of synthetic products derived from nonagricultural sources. In recent years, annual domestic use of linseed oil has ranged from 363 to 394 million pounds in contrast to the postwar high of over 700 million pounds in the early 1950's. This decrease was caused primarily by displacement by synthetic materials capable of better performance, particularly in protective coatings.

To restore the level of use of linseed oil, new or expanded markets are urgently needed. Such markets can be achieved by an adequate program of basic and applied research. Recent studies by Department scientists have resulted in commercial manufacture and sale of linseed emulsion paints for exterior use that are competitive with synthetic resin emulsion paints. Other new products from linseed oil to which Department research is contributing are protective coatings for use in curing fresh concrete and in preventing its deterioration from de-icers and freezing and thawing in winter. These new uses have improved the competitive position of linseed oil in relation to synthetics, but additional research is needed to insure maximum acceptance and consumption of linseed oil in these new markets and to provide still other new or improved products that can maintain and increase its use in all types of protective coatings.

Other new outlets can be realized by chemical modification of linseed oil to obtain materials that will find applications in the multibillion-pound annual market for products of the organic chemical industry. To furnish a sound basis for chemical modification, a broad program of basic research on linseed oil is required to furnish new leads and new concepts that will point the way to those products having the best chance for acceptance.

USDA AND COOPERATIVE PROGRAMS

The Department conducts a continuing, long-range program involving analytical, organic, and physical chemists and chemical engineers engaged in basic research on the chemical reactions of linseed oil and its component fatty acids and in the application of the knowledge gained to the development of new or improved products for the chemical and protective coating industries.

The Federal scientific effort concerned with research on industrial uses for linseed oil totals 18.2 scientist man-years. Of this number, .7 is devoted to chemical composition, physical properties and structure; 13.7 to chemical and physical investigations to improve products; .7 to microbiology and fermentation; and 4.1 to technology - process and product development.

Research at Peoria, Illinois, on chemical composition, physical properties and structure (.7 scientist man-year) involves study of mass spectroscopy for elucidating the chemical and molecular structure of glyceride oils and their derivatives.

Research at Peoria, Illinois, on chemical and physical investigations to improve products (11.4 scientist man-years) emphasizes basic studies on the chemistry of linseed oil and linseed fatty acids with the objective of discovering new reactions and derivatives having potential applications in the chemical and protective coatings industries. The work also includes basic investigations of problems related to development of emulsion paints and coatings from linseed oil and to durability of linseed oil films. During the reporting period, projects relating to water-soluble vehicles and to new vinyl ester derivatives of linseed oil were completed.

Research at Peoria, Illinois, on microbiology and fermentation (.7 scientist man-year) is concerned with exploration of the possibilities of preparing new and useful derivatives by fermentative modification of fatty acids.

Research contracts (1.3 scientist man-years*) are in effect with North Dakota State University of Agriculture and Applied Science, Fargo, North Dakota, for investigations of aldehyde oils as components of protective coatings; and with Stanford Research Institute, Menlo Park, California, for studies on properties and reactions of new vinyl copolymers of linseed oil. Also included in the total is the Northern Division's share in support of a cooperative agreement among the Division, North Dakota State University, and the National Flaxseed Processors Association. Research under this agreement is conducted at North Dakota State University and involves preparation and evaluation of linseed oil derivatives for use in improving durability of protective coatings.

Research at Peoria, Illinois, on technology - process and product development, involved engineering studies completed during the reporting period on preparation of cyclic fatty acids and aldehyde oils from linseed oil. Research contracts (2.6 scientist man-years*) are in effect with Kansas State University, Manhattan, Kansas, for studies on the use of linseed oil as a single coating for both curing and protection of concrete; with Fabric Research Laboratories, Dedham, Massachusetts, for investigations on poly(ester-acetals) and poly(amide-acetals) derived from aldehyde oils; and with Archer Daniels Midland Company, Minneapolis, Minnesota, for pilot preparation of various aldehyde oil products needed for developmental investigations. During the year, contract studies on protection of air-entrained concrete with linseed oil were completed by Kansas State University.

---

*Work covers more than one commodity; only effort allocated to flax is included in total.

The Department also sponsors research in this area under grants of PL 480 funds to foreign institutions. Chemical and physical investigations to improve products are conducted under grants to the Experiment Station for the Fats and Oils Industry, Milan, Italy, for studies on stereospecific polymerization of polyunsaturated fatty esters (2 years, 1965-1967),* and to the Regional Research Laboratory, Hyderabad, India, for exploratory research on hydroxylation reactions of linseed and safflower oils (5 years, 1963-1968). During the reporting period, research* was completed on alkaline cleavage of polyunsaturated fatty acids at Queen Mary College, University of London, London, England; and on oxidation with atmospheric oxygen to obtain new linseed and soybean oil derivatives at the Experiment Station for the Fats and Oils Industry, Milan, Italy.

Research on microbiology and toxicology involves a grant to the University of Baroda, Baroda, India, for studies on production of microbial lipases useful for modifying vegetable oils (5 years, 1965-1970).*

PROGRAM OF STATE EXPERIMENT STATIONS

State stations did not report research in this area.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Chemical Composition, Physical Properties and Structure

1. Mass spectroscopy. Mass spectroscopic investigations of chemical and molecular structure of glyceride oils and their derivatives are relevant to industrial utilization of linseed oil. Results are reported under Area 11, subheading A-1.

2. Minor constituents of linseed oil. Completion of research under a PL 480 grant to the Experiment Station for the Fats and Oils Industry, Milan, Italy, was noted last year. The final report, which was subsequently received, indicates that a number of significant results were achieved during the work. The unsaponifiable material from an Italian linseed oil was separated into hydrocarbons, esters, alcohols, and sterols. Most of the components in each of these fractions were isolated and identified. A comparison of the components in the unsaponifiable fraction from Italian linseed oil with six American linseed oils showed that the same classes of compounds were present. Generally those compounds most abundant in the Italian oil were most abundant in American oils. No significant difference could be attributed to geographic origin.

At least 43 saturated hydrocarbons (chain lengths from C_{11} to C_{35}) were found in the unsaponifiable material of linseed oil. Squalene was most

---

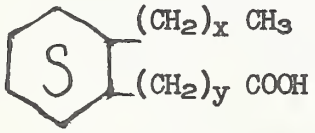
*Effort prorated between linseed and soybean oils.

prevalent among the olefinic-type hydrocarbons. The most abundant straight-chain alcohols were C_{22}, C_{24}, C_{26}, and C_{28}. The major terpene alcohols were cycloarthanol, phytol, geranyl-geraniol, 24-methylenecycloarthanol and an unidentified C_{30} alcohol that gives a positive Fitelson test but is different from butyrospermol, the positive Fitelson substance in tea seed oil. Sterols were found to make up 45 percent of the unsaponifiables and were identified as stigmasterol, β-sitosterol (the most abundant sterol), and campesterol.

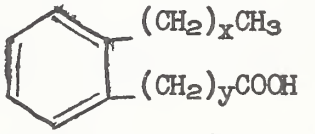
The effect of minor constituents on the spreading and wetting properties of the Italian and six American linseed oils was studied by interfacial tension, surface tension, and contact angle measurements. This area of research proved particularly difficult because these physical methods did not appear sensitive enough to show the small differences encountered. It is also possible that the minor constituents per se do not play a major role in the wetting and spreading properties of linseed oil.

B. Chemical and Physical Investigations to Improve Products

1. Cyclic fatty acids. Four of the six anticipated isomers of C_{18} saturated cyclic acids (I) and aromatic acids (II) from linseed oil have been synthesized.



I.



II. $(x + y = 10)$

The isomers prepared were those for x = 0, 1, 2, and 3. Comparisons with the mixtures obtained by alkaline cyclization of linolenic acid showed that the principal isomer formed is that corresponding to x = 2. This isomer would result from the 10,12,14-conjugated isomer of linolenic acid.

In studies of cycloaddition reactions of olefins, ethylene was found to react with cis,trans-conjugated linoleic acid only if an isomerization catalyst (NaOH) was present. Other cycloaddition products were prepared from conjugated methyl linoleate and tetrafluoroethylene, hexafluoropropylene 1,1-dichloro-2,2-difluoroethylene, and chlorotrifluoroethylene. These products were hydrogenated prior to further characterization and study of properties. Adducts were also prepared from even-numbered olefins (C_6-C_{20}) and octadecadienoic acids. Yields were about 20 percent.

Toxicity tests on cyclic alcohols revealed no irritation to the skin or eye of the rabbit. Feeding tests at the 1-percent level in the diet of rats produced growth inhibition that appeared to be due to reduced food intake rather than to direct toxic action.

2. New polymers and derivatives for use in water-soluble and other coatings. Final studies on water-soluble vehicles included examination of film properties of amine-neutralized resins containing linseed fatty acids, tris(hydroxyethyl)aminomethane, and various dibasic acids. Films were deposited from solutions containing approximately equal parts of resin and solvent (isopropanol-water). With the exception of a resin made with fumaric acid, drying times were longer than those of films deposited from toluene solution. The aqueous alcoholic resin solutions wet a steel substrate but the resulting individual films did not have uniform thickness.

A number of new polyesteramide resins having potential as coatings were synthesized. These include products (I) made from linseed dihydroxyamide (10 percent molar excess) and various dibasic acids and products (II) made from tris(hydroxyethyl)aminomethane, linseed fatty acids and various dibasic acids. The products (I) were generally poorer than those made from equimolar amounts of the same reactants, but after modification by reaction of toluene diisocyanate with the excess hydroxyl in the resins, the products gave hard films that exhibited significantly less time lapse between dry-to-touch and tack-free times. The products (II) gave films comparable in water-alkali, and toluene resistance to conventional alkyd resins. Furthermore, the experimental resins dried more rapidly and yielded much harder films. A polyurethane prepared from linseed dihydroxyamide and toluene diisocyanate gave films that dried tack-free in 4 minutes to a hardness of 54 and resisted 5 percent alkali for over 240 hours.

In studies on sulfur-containing products, some substitution was shown to occur in addition of hydrogen sulfide to the double bond of methyl oleate. Hexane 1,6-dithiol was added to linseed oil to give a product containing 1.5 hexanedithiol units per mole of glyceride. This product was slow to dry at room temperature but gave good baked films. These addition reactions were induced at 25° C. by ultraviolet light.

Films prepared from linseed oil reacted with liquid hydrogen sulfide at -70° C. under ultraviolet radiation dried very slowly at room temperature, but films baked 0.5 hour at 275° C. in CO_2 atmosphere had a hardness of 6 and resisted alkali for 30 hours. Curing of this vehicle evidently proceeds by a novel mechanism that does not involve participation of oxygen.

Contract research at Stanford Research Institute showed that in the copolymerization of C_{18} methyl esters with ethyl acrylate, styrene, and acrylonitrile reactivities were in the order: linoleate < linolenate < conjugated linoleate. Conversions of 80-93 percent were obtained in copolymerization of ethyl acrylate with linseed oil and light-bodied linseed oil. Useful copolymers could probably be made from acrylonitrile and any of the C_{18} esters. Practical copolymerizations do not, however, appear feasible with styrene.

Studies on aldehyde oil coatings under the contract at North Dakota State University showed that films with good properties could be obtained by styrenation of hydroxyethyl methacrylate acetals of aldehyde oils. Urethane resins based on soybean dialdehyde oil showed some superiority to corresponding products based on linseed monoaldehyde oil.

3. Linseed oil films and emulsions. Tensile properties of unsupported pigmented and unpigmented linseed oil films were measured. Unpigmented films were much weaker and elongated more than films containing TiO_2 or SnO_2 pigment. When water soaked, these same films retained about two-thirds of their breaking strength at 50 percent R.H. Zinc oxide gave stronger but less extensible films than did the other pigments, but, when water soaked, films containing ZnO retained only about one-fifth of their 50 percent R.H. breaking strength. Unpigmented films and those containing TiO_2 or SnO_2 showed little or no swelling when soaked in water, whereas those containing ZnO swelled 19 percent. The loss of strength coupled with swelling observed for films containing zinc oxide clearly has significant implications in relation to the well-known tendency for linseed house paints containing zinc oxide to blister, crack, and peel under adverse moisture conditions.

In research on emulsion paints, an ionic emulsion paint formulation was developed. Ingredients are nonbodied linseed oil, ZnO, TiO_2, and only 1 percent total concentration of emulsifiers and dispersing agents. The paint is viscosity stable, dries tack-free in 1 hour, passes the water test after 15 minutes, dries to a hard film on glass in 20 hours, and shows no wrinkling, blistering, or other visible change when a thoroughly dry film is soaked in water for 24 hours.

Research to find ways to increase the durability of linseed oil films has been initiated at North Dakota State University under the cooperative agreement among the Northern Division, North Dakota State University, and the National Flaxseed Processors Association. First experiments involved preparation of mercury derivatives of linseed oil containing 0.12 to 44.3 percent mercury. Derivatives containing 34.3 percent or less mercury were stable to heat, ultraviolet light, and boiling water.

4. Glyceride polymers. Last year it was noted that work had been completed under the PL 480 grant to the Experiment Station for the Fats and Oils Industry, Milan, Italy. The final report, which was subsequently received, indicated that in the thermal polymerization of linseed oil between 240-300° C., polymeric acids do not form intramolecularly in monomeric glycerides below 280° C. Polymerization occurs only between fatty acid chains in different glyceride molecules. Below 280° C., linolenic acid is responsible for most of the polymerization; linoleic and oleic acids participate significantly only at higher temperatures.

Intramolecular dimeric and trimeric acids and, perhaps by a different mechanism, dimeric glycerides may be formed simultaneously. No evidence

for trimeric glycerides was found, but tetrameric and higher glycerides were formed under the most severe conditions studied.

The structure of the dimer acids isolated from the thermally polymerized oils could not be deduced. Ozonolysis products indicated that isomerization of the double bonds occurred to give a mixture of dimer acids. A large fraction of these dimer acids appeared to contain a terminal methylene group.

Research on stereospecific polymerization was begun under the second PL 480 grant to this institution. Preliminary polymerization studies were conducted on several fatty polyene esters with a triethyl aluminum-titanium tetrachloride catalyst system. Experiments at 25° and 40-50° gave only low yields of polymer from either conjugated or nonconjugated esters.

5. Hydroxylation of linseed oil. Hydrogenation of epoxide groups without affecting olefinic unsaturation was successfully achieved. The procedure involves use of a Pd-C catalyst and a solvent, such as methanol or ethanol, containing dissolved silver nitrate. The olefinic bonds appear to be protected by π-complex formation. Patent applications covering this process have been filed in India and in the United States. Study of several alternate routes for hydroxylation was continued, but no new significant results were obtained. This research is being conducted under a PL 480 grant to the Regional Research Laboratory, Hyderabad, India.

6. Aldehyde oils and derivatives. Research on preparation of aldehyde oils and derivatives is relevant to industrial utilization of linseed oil. Results are reported under Area 10, subheadings B-1 and B-2.

C. Microbiology and Fermentation

1. Microbial modification of fatty acids. Research to explore possibilities of microbial modification of fatty acids as a means for preparing new and useful derivatives is pertinent to industrial utilization of linseed oil. Results are reported under Area 10, subheading C-1.

D. Technology - Process and Product Development

1. Cyclic fatty acids. Engineering studies on cyclic acids from linseed oil have essentially achieved the objective--development of a practical cyclization process--and have been terminated. Several significant discoveries were made during the engineering research, including the reactivity of ethylene toward conjugated fatty acids, methods for conducting cyclization in aqueous systems, and advantageous ways of separating and purifying reaction products.

2. Linseed oil coatings for concrete. The final results of the contract research at Kansas State University on protection of air-entrained concrete with linseed oil established that air-entrained concrete does need protection against freeze-thaw damage and that properly applied boiled linseed oil

effectively provides such protection. Use of the Northern Division's linseed oil emulsions rather than solutions in kerosene for application of the oil has multiplied the possible outlets for linseed antispalling compounds, since fire and health hazards are substantially eliminated. These emulsions were accepted for use in the Grant Park underground garage in Chicago.

A second contract was undertaken by Kansas State University to evaluate the performance of these emulsions as a combined curing and antispalling agent. Initial results indicated that concrete coated with boiled linseed oil emulsion developed strength comparable to that of concrete moist-cured or protected by polyethylene sheet during curing.

Field tests conducted under the Northern Division's supervision in Washington, D. C. and in Texas also reveal excellent cures and wear resistance in the cured concrete. A new field test of curing has been initiated at Wichita, Kansas, and a further field test of antispalling activity is underway at Manhattan, Kansas.

3. Aldehyde oils and derivatives. Engineering studies on preparation of aldehyde oils and derivatives is relevant to industrial utilization of linseed oil. Results are reported under Area 10, subheading D-1.

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Chemical and Physical Investigations to Improve Products

Bell, E. W., Friedrich, J. P., Gast, L. E., and Cowan, J. C. 1965. Preparation of alcohols from cyclic fatty acids. J. Am. Oil Chemists' Soc. 42(10), pp. 876-878.

DeJarlais, W. J., Gast, L. E., and Cowan, J. C. 1966. Water-solubilizable oxazoline polyester coating resins. J. Am. Oil Chemists' Soc. 43(1), pp. 41-45.

Dufek, E. J., and DeJarlais, W. J. 1965. Preparation of some linseed esters of methyl α-D-glucopyranoside using the methoxycarbonyl blocking group. J. Am. Oil Chemists' Soc. 42(12), pp. 1104-1110.

Dufek, E. J., Gast, L. E., and DeJarlais, W. J. 1965. Preparation of linseed acid chlorides. J. Am. Oil Chemists' Soc. 42(12), pp. 1060-1062.

Friedrich, J. P., Bell, E. W., and Gast, L. E. 1965. Potential synthetic lubricants: Esters of C_{18}-saturated cyclic acids. J. Am. Oil Chemists' Soc. 42(7), pp. 643-645.

Gast, L. E., Schneider, W. J., and Cowan, J. C. 1966. Polyester amides from linseed oil for protective coatings. J. Am. Oil Chemists' Soc. 43(6), pp. 418-421.

Princen, L. H. 1965. Pigment interactions in aqueous media. Offic. Dig., Federation Soc. Paint Technol. 37(485), pp. 766-781.

Schwab, A. W., Stolp, J. A., Gast, L. E., and Cowan, J. C. 1966. N-2-Mercaptoethyl amides of fatty acids--A new class of derivatives. J. Am. Oil Chemists' Soc. 43(1), pp. 30-32.

Subbarao, R., Rao, G. V., and Achaya, K. T. (Regional Research Laboratory, Hyderabad, India). 1966. Protection of unsaturation during heterogeneous catalytic hydrogenation of aliphatic epoxy to hydroxy groups. Tetrahedron Letters (4), pp. 379-381.*

Uksila, E., Roine, P., Syvaoja, E.-L., and Alivaara, A. (University of Helsinki, Helsinki, Finland). 1963. Fractionation of linseed oil fatty acids by crystallization. Acta Chem. Scand. 17(10), pp. 2622-2627.*

---

*Research supported by PL 480 funds.

Technology - Process and Product Development

Beal, R. E., Eisenhauer, R. A., and Sohns, V. E. 1965. Production of cyclic fatty acids: Water as the reaction solvent. J. Am. Oil Chemists' Soc. 42(12), pp. 1115-1119.

Faulkner, R. N., and O'Neill, L. A. June 28, 1966. Film-forming organometallic derivatives of fatty acids. U. S. Patent 3,258,475.*

Kubie, W. L., Sr. Jan. 11, 1966. Single application linseed oil-to-water emulsions for curing and/or preventing spalling on concrete. U. S. Patent 3,228,777.

Pryde, E. H. Dec. 14, 1965. Crosslinked poly- and interpoly(amide-acetals). U. S. Patent 3,223,683.

Scholer, C. H., and Best, C. H. (Kansas State University, Manhattan, Kansas). 1965. Concrete curing and surface protection with linseed oil. Kansas Eng. Exp. Station, Special Rept. 60, 22 pp.

RELATED PUBLICATIONS OF STATE EXPERIMENT STATIONS

None.

*Research supported by PL 480 funds.

SOYBEAN UTILIZATION - INDUSTRIAL PRODUCTS
Northern Utilization Research and Development Division, ARS

Problem. As an industrial oil, soybean oil is faced with growing competition from synthetic products derived from nonagricultural sources. As an industrial source of linoleic acid, soybean fatty acids must also compete with tall oil fatty acids, a byproduct of paper manufacture. Largely because of effective research, nonfood usage of soybean oil has rather consistently accounted for about 10 percent of domestic disappearance. The best opportunity for maintaining or increasing industrial applications of soybean oil is to be found in development of nontraditional products that can compete with synthetics in the multibillion-pound market for resins, fibers, coatings, plastics, plasticizers, pesticides, and paper and textile chemicals. To achieve the objective, more fundamental information is needed on reactions of soybean oil, especially those that will preserve the glyceride structure, and on the physical and chemical properties of the products.

USDA AND COOPERATIVE PROGRAMS

The Department has a continuing, long-range program involving analytical, organic, and physical chemists, and chemical engineers engaged in basic and applied research to obtain new information on chemical reactions of soybean oil and its components and to use this information to develop new or improved products for use by the chemical and other industries. In addition, microbiologists are engaged in a limited study of the possibilities of fermentative modification of fatty acids derived from soybean oil.

The Federal scientific effort for research on industrial utilization of soybean oil totals 13.7 scientist man-years. Of this number, .8 is devoted to chemical composition, physical properties and structure; 7.5 to chemical and physical investigations to improve products; 1.7 to microbiology and fermentation; and 3.7 to technology - process and product development.

Research at Peoria, Illinois, on chemical composition, physical properties and structure (.8 scientist man-year) is devoted to mass spectrometric investigations of chemical and molecular structure of glyceride oils and their derivatives.

Research on chemical and physical investigations to improve products in progress at Peoria, Illinois (6.8 scientist man-years), emphasizes studies of aldehyde derivatives of soybean oil. A research contract with the University of Illinois, Urbana, Illinois, provides for basic studies on the mechanism of homogeneous hydrogenation with organometallic catalysts. A portion of this effort is allocated to industrial utilization of soybean oil (.4 scientist man-year). Also, a research contract with North Dakota State

University of Agriculture and Applied Science, Fargo, North Dakota, provides for investigations of aldehyde oils as components of protective coatings (.3 scientist man-year*).

Research at Peoria, Illinois, on microbiology and fermentation (1.7 scientist man-years) involves exploration of possibilities for producing industrially useful derivatives by microbial conversion of fatty acids.

Research at Peoria, Illinois, on technology - process and product development involved engineering studies on production of aldehyde oils from soybean oil (1.4 scientist man-years). This work was completed by the close of the reporting year. Research contracts (2.3 scientist man-years*) are in effect with Fabric Research Laboratories, Dedham, Massachusetts, for investigations on poly(ester-acetals) and poly(amide-acetals) derived from aldehyde oils; and with Archer Daniels Midland Company, Minneapolis, Minnesota, for pilot preparation of various aldehyde oil products needed for developmental investigations.

The Department also sponsors research in this area under grants of PL 480 funds to foreign institutions. Effort is prorated between soybean and linseed oils. Chemical and physical investigations to improve products are pursued under a grant to the Experiment Station for the Fats and Oils Industry, Milan, Italy, for studies on stereospecific polymerization of polyunsaturated fatty esters (2 years, 1965-1967). During the year, research was completed on alkaline cleavage of polyunsaturated fatty acids at Queen Mary College, University of London, London, England; and on oxidation with atmospheric oxygen to obtain new linseed and soybean oil derivatives at the Experiment Station for the Fats and Oils Industry, Milan, Italy.

Research on microbiology and toxicology involves a grant to the University of Baroda, Baroda, India, for studies on production of microbial lipases useful for modifying vegetable oils (5 years, 1965-1970).

PROGRAM OF STATE EXPERIMENT STATIONS

A total of 4.0 scientist man-years is devoted to this area of research.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Chemical Composition, Physical Properties and Structure

1. Mass spectroscopy. Mass spectrometric investigations of chemical and molecular structure of glyceride oils and their derivatives are relevant to industrial utilization of soybean oil. Results are reported under Area 11, subheading A-1.

---

*Work covers more than one commodity; only effort allocated to soybeans is included in total.

B. Chemical and Physical Investigations to Improve Products

1. Oxidative cleavage of unsaturated fatty acids. Studies were conducted on two novel and potentially practical ozonization methods. Thermal decomposition of ozonolysis products in water gave 40-50 percent yields of aldehyde. Reductive decomposition in the presence of propylene appeared to form no propylene oxide and gave aldehyde yields equivalent to those in its absence.

Optimum ozonolysis conditions developed for preparing methyl azelaaldehydate from methyl oleate were not directly applicable to methyl erucate because the erucate and the expected methyl brassylaldehydate are less soluble in the reaction solvent. Preliminary results with erucic acid, which is more soluble in acetic acid/butanol, were encouraging.

2. Aldehyde oil derivatives. Studies during the past year reflect the versatility of the aldehyde group for derivatization and have significantly augmented the type and number of potentially useful products obtainable from soybean and other oils via the ozonization route.

Either secondary or tertiary amines were prepared in yields of 80-85 percent by reductive alkylation of ammonia with pelargonaldehyde and methyl azelaaldehyde (MAZ). Type of product is determined by choice of catalyst and solvent system. 9-Aminononanamide, a potential source of tough polyamides having low water absorption, was prepared in over 30-percent isolated yield by simultaneous amination and ammonolysis of MAZ. Methyl brassylaldehydate could be converted to methyl 13-aminotridecanoate in excellent yields. Bis(8-carbomethoxyoctyl)amine resulted in 42-percent isolated yield from amination of MAZ under anhydrous conditions. Its N-acetyl derivative is a liquid that does not solidify at -70° C.

Bulk polymerization of MAZ glycerol acetal with calcium oxide catalyst gave polymers with molecular weights of 7,000 to 14,460 and melting points of 40 to over 100° C. Some of these polymers may have potential as elastomers. Two of the four possible isomers of MAZ glycerol acetal were isolated as crystalline solids and characterized.

Zinc acetate and lead octoate were the most effective of 11 catalysts tested for formation of crosslinked adherent films on glass from poly(ester-acetals) and poly(amide-acetals) derived from the pentaerythritol acetal of MAZ. Temperatures above 275° C. and times exceeding 30 minutes were, however, required for film formation. The films had good resistance to water, organic solvents, and 5 percent hydrochloric acid. The poly(ester-acetal) films were degraded by alkali whereas the poly(amide-acetal) films were more resistant.

Soybean oil ozonolysis products were effective peroxidic initiators for crosslinking of unsaturated polyester resins. Preliminary test samples showed both advantages and disadvantages in comparison to controls cured with benzoyl peroxide.

Polymethylol compounds were prepared in 90-percent crude yields by alkaline condensation of formaldehyde with hexanal or nonanal. These aldehydes result from ozonolysis of linoleate and oleate, respectively. Compounds of this type have applications in alkyd resins and as plasticizers and lubricants.

3. Cyclic fatty acids. Studies on the preparation of cyclic fatty acids are relevant to industrial utilization of soybean oil. Results are reported under Area 12, subheading C-1.

4. New chemical products. Research under the PL 480 grants to Queen Mary College, University of London, London, England, and to the Experiment Station for the Fats and Oils Industry, Milan, Italy, has been completed but final reports have not been received. These grants cover studies on alkaline cleavage of polyunsaturated fatty acids and oxidation of such acids with atmospheric oxygen, respectively.

C. Microbiology and Fermentation

1. Microbial modification of fatty acids. Use of concentrated, non-growing cell suspensions was found to be a more sensitive means than conventional fermentation for detecting microbial modification of fatty acids. Three cultures have been found that modify pelargonic acid and seven that modify oleic acid. Three strains of organisms isolated from soil were found to produce 10-ketostearic acid from up to 20 percent of the 1-percent concentration of oleic acid supplied. The conversion can be consistently accomplished by conventional fermentation techniques.

D. Technology - Process and Product Development

1. Aldehyde oils and derivatives. In engineering research, an improved method for contacting ozone with soybean oil-water emulsions to obtain nearly complete reaction was developed. Products containing 2.25 aldehyde groups per molecule (theoretical maximum 2.45) were obtained. Procedures for conversion of aldehyde oils to acetals in nearly quantitative yields were also developed.

Undesired water-in-oil emulsions encountered in use of this method for ozonolysis could be avoided by using a mixture of equal weights of oil and nonanal, hexanal, or their acetals. These aldehydes, of course, are themselves products of reductive ozonolysis of the oil.

Statistically designed experiments at Archer Daniels Midland Company have identified the significant variables involved in preparation of aldehydes from soybean methyl esters. This contractor has also reported that ozonide formed in the absence of a solvent undergoes rapid, total, and very exothermic decomposition when heated to 120° C.

Contract research at Fabric Research Laboratories has resulted in preparation and characterization of specified linear poly(ester-acetals) and poly(amide-acetals) having molecular weights of 5,000-10,000 and cyclic acetal rings of 5-, 6-, and 7-members. These products are suitable for the studies on crosslinking and adhesion. Hydroxyester and diester acetals derived from methyl azelaaldehydate were successfully converted to interpolymers containing various commercial diesters, glycols, and amines.

2. Cyclic fatty acids. Engineering studies on preparation of cyclic fatty acids are relevant to industrial utilization of soybean oil. Results are reported under Area 12, subheading D-1.

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Chemical and Physical Investigations to Improve Products

Anders, D. E., and Pryde, E. H. 1966. Infrared spectrophotometric procedure for determining azelaaldehydic acid derivatives. J. Am. Oil Chemists' Soc. 43(5), pp. 305-306.

Anders, D. E., Pryde, E. H., and Cowan, J. C. 1965. Amines from aldehydes derived from the ozonization of soybean esters. J. Am. Oil Chemists' Soc. 42(10), pp. 824-827.

Awl, R. A., and Pryde, E. H. 1966. Reduction of methyl oleate ozonolysis products to aldehydes with activated zinc. J. Am. Oil Chemists' Soc. 43(1), pp. 35-37.

Fedeli, E., Valentini, A. F., Lanzani, A., and Jacini, G. (Experiment Station for the Fats and Oils Industry, Milan, Italy). 1965. Ricerche sull'autossidazione delle sostanze grasse polinsature. V. [Research on the autoxidation of polyunsaturated fatty materials. V.] Riv. Ital. Sostanze Grasse 42(10), pp. 488-492.*

Miller, W. R., Pryde, E. H., Cowan, J. C., and Teeter, H. M. 1965. Nitrosyl chloride adduct of methyl oleate. J. Am. Oil Chemists' Soc. 42(8), pp. 713-716.

Moore, D. J., Pryde, E. H., and Cowan, J. C. 1965. A comparison of participating solvents during ozonization. J. Am. Oil Chemists' Soc. 42(10), pp. 894-898.

Pryde, E. H. 1965. Industrially important reactions [of fatty acids]. In "Kirk-Othmer Encyclopedia of Chemical Technology," 2nd ed., John Wiley & Sons, Inc., New York, Vol. 8, pp. 818-824.

Pryde, E. H. 1965. Economic aspects [of fatty acids]. In "Kirk-Othmer Encyclopedia of Chemical Technology," 2nd ed., John Wiley & Sons, Inc., New York, Vol. 8, pp. 839-845.

Pryde, E. H., Moore, D. J., Cowan, J. C., Palm, W. E.,[1] and Witnauer, L. P.[1] ([1]East. Util. Res. Develop. Div., Philadelphia, Pennsylvania). 1966. Azelaaldehydic acid ester-acetal derivatives as plasticizers for poly(vinyl chloride). Polymer Eng. Sci. 6(1), pp. 60-65.

Sharpe, R. E.,[1] Berry, D. A.,[1] Pryde, E. H., and Cowan, J. C. ([1]Battelle Memorial Institute, Columbus, Ohio). 1965. Instrumental study of aldehyde oils and their reaction with selected amines. J. Am. Oil Chemists' Soc. 42(10), pp. 835-838.

---

*Research supported by PL 480 funds.

Uksila, E., Mattila, I., and Roine, P. (University of Helsinki, Helsinki, Finland). 1963. Fractionation of soybean oil fatty acids by crystallization as "acid" sodium soaps. Suomen Kemistilehti B 36(4), pp. 84-88.*

Technology - Process and Product Development

Beal, R. E. 1966. Removal of metal catalysts from aldehyde oils. J. Am. Oil Chemists' Soc. 43(3), pp. 122-124.

RELATED PUBLICATIONS OF STATE EXPERIMENT STATIONS

Chemical Composition, Physical Properties and Structure

Barnes, R. H., Kwong, E., and Fiala, G. 1965. Effect of penicillin added to an unheated soybean diet on cystine excretion in feces of the rat. J. Nutrition 85(2), pp. 123-126. (N. Y.)

Barnes, R. H., Kwong, E., and Fiala, G. 1965. Prevention of coprophagy in the rat and the growth-stimulating effects of methionine, cystine and penicillin when added to diets containing unheated soybeans. J. Nutrition 85(2), pp. 127-131. (N. Y.)

Barnes, R. H., and Kwong, E. 1965. Effect of soybean trypsin inhibitor and penicillin on cystine biosynthesis in the pancreas and its transport as exocrine protein secretion in the intestinal tract of the rat. J. Nutrition 86, pp. 245-252. (N. Y.)

Black, B. C., and Hammond, E. G. 1965. Separation by dielectric distribution: Application to the isolation and purification of soybean phosphatides and bacterial spores. J. Am. Oil Chemists' Soc. 42(11), pp. 936-939. (Iowa)

Borchers, R. 1965. Environmental temperature and growth inhibition of weanling rats fed raw soybean rations. J. Nutrition 85, pp. 205-206. (Nebr.)

Borchers, R., Anderson, S. M., and Spelts, J. 1965. Rate of respiratory carbon-14 dioxide excretion after injection of C14-amino acids in rats fed raw soybean meal. J. Nutrition 86, pp. 253-255. (Nebr.)

Elwood, J. K., Herbst, R. M., and Kilgour, G. L. 1965. Tetrazole analogues of glutamic acid. I. Reaction with glutamic dehydrogenase. J. Biol. Chem. 240, pp. 2073-2076. (Mich.)

---

*Research supported by PL 480 funds.

Hegsted, D. M., and Chang, Yet-oy. 1965. Protein utilization in growing rats at different levels of intake. J. Nutrition 87, pp. 19-25. (Wyo.)

Janado, M., and Nishida, T. 1965. Interaction of dextran sulfate with low-density lipoproteins of plasma. J. Lipid Research 6(3), pp. 331-334. (Ill.)

Johnson, R. M., and Ito, T. 1965. Effects of a nutritional deficiency of unsaturated fats on the distribution of fatty acids in rat liver mitochondrial phospholipids. J. Lipid Research 6(1), pp. 75-79. (Ohio)

Miller, G. J., and Ellis, W. W. 1965. Effects of dietary lipid and diethylstilbestrol upon liver fatty acids of choline-deficient rats. J. Nutrition 86, pp. 399-405. (Wyo.)

Miller, E. R., Ullrey, D. E., Zutaut, C. L., Hoefer, J. A., and Luecke, R. L. 1965. Comparisons of casein and soy proteins upon mineral balance and vitamin D_2 requirement of the baby pig. J. Nutrition 85(4), pp. 347-354. (Mich.)

Petersen, H. A., and Foster, J. F. 1965. The microheterogeneity of plasma albumins. III. Comparison of some physicochemical properties of subfractions. J. Biol. Chem. 240, pp. 3858-3865. (Ind.)

Rand, P. G., and Quackenbush, F. W. 1965. Effects of purified cis- and trans-fatty acid derivatives on the hypercholesterolemic rat. J. Nutrition 87, pp. 489-492. (Ind.)

Roberts, R. C., and Briggs, D. R. 1965. Isolation and characterization of the 7S component of soybean globulins. Cereal Chem. 42, pp. 71-85. (Minn.)

Smith, R. E., and Scott, H. M. 1965. Use of free amino acid concentrations in blood plasma in evaluating the amino acid adequacy of intact proteins for chick growth. II. Free amino acid patterns of blood plasma of chicks fed sesame and raw, heated and overheated soybean meals. J. Nutrition 86(1), pp. 45-50. (Ill.)

Starnes, W. J., and Hadley, H. H. 1965. Chlorophyll content of various strains of soybeans, Glycine max (L.) Merrill. Crop Sci. 5, pp. 9-11. (Ill.)

Zimmerman, R. A., and Scott, H. M. 1965. Interrelationship of plasma amino acid levels and weight gain in the chick as influenced by suboptimal and superoptimal dietary concentrations of single amino acids. J. Nutrition 87, pp. 13-18. (Ill.)

Technology - Process and Product Development

Nakamura, H., and Hieronymus, T. A. 1965. Structure of the soybean processing industry. Ill. Agr. Exp. Sta. Bull. 706, pp. 1-84. (Ill.)

SOYBEAN UTILIZATION - FOOD
Northern Utilization Research and Development Division, ARS

Problem. Worldwide shortages of dietary protein and of food fats pose a problem that urgently demands solution. Since soybeans can furnish both of these nutritionally essential substances, foreign markets provide a promising outlet for the rapidly increasing production of soybeans in the United States.

U. S. soybeans could play a dominant role in alleviating the protein shortage in developing countries and elsewhere around the world, if soybean meal, flour, protein, and protein concentrates can be successfully used in food products tailored to meet the various nutritional and palatability requirements. Achievement of the maximum share of foreign food markets will require intensive research to acquire more basic information on components that affect nutritional quality, flavor, and other important characteristics of soybean food products. In addition, better knowledge of the effects of processing on these components is needed.

Soybean oil, now the major edible oil of the United States, is the most important source of nutritionally important linoleic acid. However, this oil contains an unstable component (linolenic acid) that limits its use as a liquid oil. To increase opportunities for foreign utilization of soybean oil, more information is needed to show how to eliminate unstable linolenic acid without loss of nutritive value; to determine the extent to which minor constituents influence flavor and other properties of the oil; and to discover methods for modifying hydrogenated soybean oil to achieve desired functional properties such as melting point and texture. A broad program of basic and applied research is required to achieve the objective.

USDA AND COOPERATIVE PROGRAMS

The Department has a continuing, long-range program involving analytical, organic, and physical chemists, biochemists, and chemical engineers engaged in basic and applied research on edible uses of soybean oil, meal, and protein. Food technologists are also required by the program in connection with formulation and organoleptic evaluation of edible products. Objectives of research on edible soybean oil are to identify undesirable flavor components of the oil, to develop basic information on the chemical changes and mechanisms involved in formation or suppression of these components, and to apply the knowledge gained to the development of edible soybean oil having improved oxidative, thermal, and organoleptic stability. Objectives of research on soybean meal and protein are to obtain basic information on the characterization of proteins, enzymes, and other components of soybean meal and to apply the knowledge gained to solution of problems encountered in processing and utilization of soybean meal and protein in food products for foreign consumption.

The Federal scientific effort for research on utilization of soybeans in foods totals 27.1 scientist man-years. Of this number, 6.6 are devoted to chemical composition and physical properties; 16.4 to flavor; .3 to color, texture and other quality factors; .5 to microbiology and toxicology; and 3.3 to technology - process and product development.

Research at Peoria, Illinois, on chemical composition and physical properties (6.6 scientist man-years) includes basic studies on the phenomenon of heat-gelation of alcohol-washed soybean protein and investigation of mass spectroscopy in elucidation of the chemical and molecular structure of glyceride oils and their derivatives. During the reporting period, studies on characterization of components of whey proteins were completed.

Research at Peoria, Illinois, on flavor (14.7 scientist man-years) emphasizes basic and applied studies on selective hydrogenation as a means of stabilizing soybean oil by removal of linolenate. The work includes chemical, physical, and organoleptic evaluation of edible soybean oil products. Other research is devoted to basic studies of the influence of minor constituents of the soybean on the flavor and other edible qualities of soybean protein food products. Research contracts (1.2 scientist man-years*) are in effect at Rutgers, The State University, New Brunswick, New Jersey, for basic studies on heterogeneous catalysts; and at the University of Illinois, Urbana, Illinois, for basic research on homogeneous catalysts. An additional contract at the University of Illinois provides for studies of the mechanism of homogeneous catalysts of hydrogenation by organoleptic complexes. A portion of this effort (.5 scientist man-year) is allocated to research on food uses of soybean oil. During the year, IIT Research Institute, Chicago, Illinois, completed a research contract on development of heterogeneous selective hydrogenation catalysts.

Research on color, texture, and other quality factors involves a research contract (.3 scientist man-year) at the University of Illinois, Urbana, Illinois, for investigation of factors possibly present in soybeans that could cause digestive disturbances.

Research on microbiology and toxicology conducted at Peoria, Illinois, (.5 scientist man-year*) is concerned with a survey to estimate the incidence of aflatoxin in commercial samples of soybeans.

Research at Peoria, Illinois, on technology - process and product development (3.3 scientist man-years) includes engineering studies on production of full-fat soy flour by processes suitable for use in developing countries and on pilot-plant-scale hydrogenation of soybean oil with new selective heterogeneous catalysts. The work on full-fat soy flour is supported by the Agency for International Development and involves cooperation with UNICEF.

---

*Work covers more than one commodity; only effort allocated to soybeans is included in total.

The Department also sponsors research on food utilization of soybeans conducted by foreign institutions under grants of PL 480 funds. Research on chemical composition and physical properties involves grants to the Weizmann Institute of Science, Rehovot, Israel, for research on complexes between soybean protein and other components of the meal (5 years, 1961-1966); the University of Tokyo, Tokyo, Japan, for studies on soybean sterols in defatted meal (4 years, 1963-1967); and Kagawa University, Takamatsu, Japan, for investigations of enzymatic hydrolysis of soybean oligosaccharides (3 years, 1966-1969). During the reporting period, research was completed on soybean polysaccharides at the University of Edinburgh, Edinburgh, Scotland; on a chromatographic study of soybean sugars and oligosaccharides at Kagawa University, Takamatsu, Japan; and on soybean saponins at Hebrew University, Rehovot, Israel.

Research on flavor is conducted under grants to the University of Granada, Granada, Spain, for studies on the effect of processing on frying quality of soybean oil (5 years, 1962-1967); Toyo University, Kawagoe, Saitama-ken, Japan, for research on hydrogenation of soybean oil (5 years, 1962-1967); Experiment Station for the Fats and Oils Industry, Milan, Italy, for studies on certain metal chelate compounds as catalysts for selective hydrogenation of soybean oil (2 years, 1965-1967); and University of Tokyo, Tokyo, Japan, for investigations on the flavor components of enzymatically or chemically modified soybean meal and proteins (3 years, 1964-1967). During the year, studies on soybean sterols and their effect on stability of the oil were completed at Gdansk Polytechnic, Gdansk, Poland.

Research on color, texture, and other quality factors involves a grant to Sugiyama Chemical Research Institute, Tokyo, Japan, for basic studies on the color reversion of soybean oil (2 years, 1964-1966).

Research on microbiology and toxicology involves grants to the Central Miso Institute, Tokyo, Japan, for studies on miso made from dehulled soybean grits (4 years, 1962-1966); Bar-Ilan University, Ramat Gan, Israel, for studies on miso-type food products for use in Israel (3 years, 1962-1965); Japan Tofu Association, Tokyo, Japan, for studies on the use of U. S. soybeans for making tofu (4 years, 1963-1967); Institute of Chemistry, Academia Sinica, Taipei, Taiwan, for investigation on preparing Chinese cheese from soybeans (5 years, 1963-1968); Noda Institute for Scientific Research, Noda-shi, Chiba-ken, Japan, for studies on improved strains of Saccharomyces rouxii for making shoyu and miso (5 years, 1963-1968); Japan Shoyu Research Institute, Tokyo, Japan, for comparative evaluation of U. S. and Japanese soybeans and processing methods for making soy sauce (3 years, 1965-1968); and Tokyo University of Education, Tokyo, Japan, for basic studies on development of foods from enzymatically treated soybean protein concentrates (3 years, 1965-1968).

Technology - process and product development involves a grant to the Israel Institute of Technology, Haifa, Israel, for evaluation of the quality of isolated soybean protein for use in Israeli foods (4 years, 1962-1966).

PROGRAM OF STATE EXPERIMENT STATIONS

A total of 4.0 scientist man-years is devoted to this area of research.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Chemical Composition and Physical Properties

1. Mass spectroscopy of glyceride oils and derivatives. To obtain basic information on the mechanism of catalytic hydrogenation, mass spectroscopic studies were made of the catalytic deuteration of methyl oleate. Results obtained with this labeled system indicated that on platinum catalysts absorption-desorption occurs at about the same rate as hydrogenation, while on palladium absorption-desorption is about five times as fast as hydrogenation. By combination of mass and infrared spectral techniques, procedures were developed for determining not only the number of deuterium atoms in a molecule, but also the number of -CHD- and of $-CD_2-$ groups.

2. Basic studies on soybean protein. "Fingerprint peptide maps" of the four soybean trypsin inhibitors indicated that inhibitors A_1 and B_2 may both be derived from A_2 but that B_1 is definitely different. The inhibitors were also examined by polyacrylamide gel electrophoresis after reduction and reduction-alkylation. Inhibitors A_2 and B_1 behaved differently, whereas A_1 and B_2 resembled each other but differed from A_2 and B_1. Inhibitors A_1, B_1, and B_2 appeared to be heterogeneous. At a pH of 3.75, where no complex between trypsin and soybean trypsin inhibitor exists, trypsin cleaved the inhibitor with formation of another major protein component.

Insolubilization of soybean protein during acid precipitation (pH 4.5) was found to involve both reversible and irreversible reactions. The reversible insolubilization results from disulfide polymer formation and could be reversed with mercaptoethanol. Irreversible insolubilization comprised an initial rapid change involving the 7S fraction followed by a slower decrease in solubility over several hours during which the 2S, 7S, and >15S fractions decreased slowly. Precipitation in the presence of sulfhydryl blocking agents had no effect. On the other hand, dialysis of a water extract of soybean meal against 10 percent sodium chloride and then distilled water resulted in a significant decrease in the amount of insolubilization. This observation suggests that low-molecular-weight components participate in insolubilization. A procedure was devised for quantitative measurement of insolubilization by determination of solubility of acid-precipitated protein in a buffer in the presence and absence of mercaptoethanol. With freshly prepared laboratory samples, only small amounts of protein were solubilized by mercaptoethanol. Commercial samples showed wide variation in the amount of protein solubilized.

3. Minor constituents of soybeans. These studies are being conducted by several foreign institutions under PL 480 grants. Research at the Weizmann

Institute of Science, Rehovot, Israel, has resulted in isolation of three new hemagglutinins. The presence of multiple forms of hemagglutinin and trypsin inhibitor (see item 2, above) strongly suggests proteolytic degradation of parent molecules during protein isolation.

Investigators at Hebrew University, Rehovot, Israel, isolated and characterized a new saponin from soybeans, bringing the total to five known to be present. A comparative study of soybean and alfalfa saponins showed that the two types differ sharply in biological properties, although certain of their components are chemically similar; alfalfa saponins inhibited chick growth, whereas soybean saponins did not. No varietal differences either in saponin content or activity were found in a comparison of six soybean varieties. Although pure saponins isolated from soybeans killed fish by inhibiting cholinesterase (a nerve enzyme) and inhibited food digestive enzymes in certain insect larvae, tests showed that their presence in soybean meal is not detrimental to its nutritive value. In controlled feeding studies no deleterious effect was noted when these saponins were added to diets of chicks or rats in a concentration of five times their normal content in soybean meal. The enzyme-inhibiting effect of the purified saponins was fully counteracted by mixing them with soybean protein, which appeared to complex and thus inactivate them. This project has been completed.

At the University of Tokyo, Tokyo, Japan, soybean sterols have been shown to exist in four different forms: free, ester, glucoside, and acylated glucoside. A chromatographic method for separation of the four forms has been developed.

Studies on soybean polysaccharides were completed at the University of Edinburgh, Edinburgh, Scotland. Results of this research showed that dehulled, defatted soybean meal, which includes food-grade soy flour, contains about 30 percent carbohydrates, of which one-half is oligosaccharides: 8.2% sucrose; 5.5% stachyose; and 1.2% raffinose. The other half is polysaccharides: 8-10% of a neutral arabinogalactan; 5-7% of an acidic polysaccharide complex resembling pectic and tragacanthic acids; and possibly 1% of an arabinan. Soybean hulls have four kinds of polysaccharides: 9-11% galactomannan; 10-12% of the acidic, pectin-type polysaccharide; 9-10% xylan hemicellulose; and 40% cellulose. Knowledge of the polysaccharides opens the way for processing studies directed toward modifying functional and nutritional properties of soybean flours. For example, the acidic polysaccharides offer possibilities for hydrolysis by pectinase to increase solubility of the meal and possibly to increase digestibility.

Studies on sugars and oligosaccharides in soybeans were completed at Kagawa University, Takamatsu, Japan, but the final report has not yet been received. This investigation is being extended under a second grant to the same institution for research on enzymatic hydrolysis of soybean oligosaccharides.

B. Flavor

1. Selective hydrogenation - homogeneous catalysis. Mixtures of chloroplatinic acid and stannous chloride were found to serve as catalysts for the homogeneous hydrogenation of methyl linolenate in methanol-benzene solution. At 65° C. and 220-500 p.s.i., dienes and diene-trienes were the major products. Isomerization was extensive. Further study of the catalytic activity of platinum-tin complexes showed that conjugation was an important initial step preceding reduction. In fact, with the complex $[(C_6H_5)_3P]_2Pt \cdot HSnCl_3$ (I), linolenate underwent more conjugation than reduction to diene. The procedure for producing conjugated oils via iron tricarbonyl complexes (formed by reaction with iron pentacarbonyl) has been improved by the discovery that the complexes can be decomposed with carbon monoxide to yield the conjugated oil and regenerate iron pentacarbonyl for reuse in complex formation. For example, when a soybean oil complex was treated at 180° C. with CO at 3,600 p.s.i., 84 percent of the theoretical yield of iron pentacarbonyl was formed and 82 percent of the polyunsaturates in the oil were conjugated. A study of the ^{13}C NMR spectra of linoleate and butadiene complexes with iron tricarbonyl showed that bonding between iron and the olefinic systems resembles that present in ferrocene.

At the University of Illinois, contract studies on homogeneous hydrogenation showed that methanol was required in the solvent system to achieve selectivity in the use of platinum-tin complexes for hydrogenation of methyl linoleate to monoenes and conjugated dienes. Without methanol, stearate became an important product. These complexes also extensively isomerized methyl oleate if methanol was present. At the University of Illinois, the arsenic- and antimony-containing analogs of I were prepared and compared with I in hydrogenation of soybean esters. Catalytic activity was greatest for the arsenic derivative, whereas conjugation produced was least (64.6 percent) for I and greatest (77.2 percent) for the antimony derivative. Related triphenylphosphine complexes of iron, cobalt, and nickel also were examined. Dibromo-bis-(triphenylphosphine)-nickel catalyzed hydrogenation of methyl linoleate to monoenes. The dichloro derivative showed little activity and addition of stannous chloride decreased both activity and selectivity of the dibromo compound. Di- and trichloro-bis-(triphenylphosphine)-iron both catalyzed reduction of linoleate to stearate only. Dichloro-bis-(triphenylphosphine)-cobalt was inactive.

Under a PL 480 grant to the Experiment Station for the Fats and Oils Industry, Milan, Italy, a novel procedure was developed for preparation of metal chelates by chromatography on adsorbent impregnated with metal salts. These chelates are for use in studies on selective hydrogenation.

2. Selective hydrogenation - heterogeneous catalysis. A laboratory process for preparation of methyl cis-15-octadecenoate was developed. It is based on use of chromatography with a silver-treated macroreticular exchange resin to separate the mixture of 9-, 12-, and 15-octadecenoates isolated by counter current distribution of hydrazine-reduced linoleate. Mathematical theory

and a digital computer program were developed to describe the various modes of operation of counter double current distribution and to provide information needed for determining optimum operating conditions and for interpreting results. A program to generate overlapping distribution functions was written for a general-purpose analog computer. The position, width, amplitude, and skewing of each function can be varied to match experimental data. Component percentages can be calculated from integral curves. Matching is done rapidly by means of an oscilloscope, and computer settings are related to parameters of the distribution. These achievements represent important advances in our capacity to analyze complex reaction mixtures resulting from hydrogenation and to provide meaningful interpretation of the experimental data.

Contract research at IIT Research Institute on preparation of new heterogeneous catalysts has been completed. Study of various metals supported on molecular sieves revealed catalysts that are nonselective for hydrogenation of the 15,16 double bond of methyl linolenate but that are selective for this double bond when linolenate is incorporated into the triglyceride structure of an oil. In general, these catalysts attack linolenate three times more rapidly than linoleate.

3. Evaluation of edible soybean oil products. Soybean oils hydrogenated with commercial copper-barium chromate catalysts were evaluated for quality. Initial flavor scores for all oils treated with citric acid were good. These oils had less oxidative stability than comparable oils hydrogenated with nickel catalysts, but citric acid treatment gave improved stability to both types.

In chromatography of hydrocarbons on activated alumina, procedures have been discovered that achieve one or more of the following improvements: (1) extension of upper limit to hydrocarbons above C_{10}; (2) selective and irreversible adsorption of olefins, including separation of cis,trans isomers; (3) efficient and rapid hydrocarbon resolution; and (4) controlling retention time and column efficiency by appropriate selection of the carrier gas. Accurate determination of hydrocarbons present in soybean oil is important to development of analytical methodology for rapid and objective evaluation of oil quality.

Scientists at the University of Granada, Granada, Spain, have developed an accurate yet simple test for the measurement of fat penetration in food products (error of 0.01 percent based on 2,500 measurements) and have shown that cottonseed oil and olive oil penetrate less than soybean oil, winterized soybean oil, or peanut oil. Results continue to show that acceptance of soybean oil is equal to that of olive oil and that soybean oil is still more acceptable than winterized soybean oil. Study of vessels for frying indicated that with olive oil more acceptable chips were obtained when a glass vessel was used. With soybean oil and winterized soybean oil, glass, aluminum, and steel vessels were equally suitable.

4. Effect of sterols on flavor stability. Research under a PL 480 grant to Gdansk Polytechnic, Gdansk, Poland, has shown that although the bleaching process caused drastic transformation of sterols in soybean oil, neither sterols nor their transformation compounds were important in the initial stages of oil autoxidation and thus had little influence on the development of undesirable flavors and odors in soybean oil. This project has been completed.

5. Flavor components of soybean meal and protein. Lipids extracted from defatted soybean meal were separated into two groups designated "residual oil" and "bound lipids." The flavor components of the defatted meal were found to be present in the bound lipids and in a non-lipid fraction. Phenolic constituents appear to be present in quantities too small to influence flavor characteristics.

At the University of Tokyo, Tokyo, Japan, volatile carbonyl compounds from soybeans and defatted soybean flour have been partially identified. They are similar, in part, to the volatile flavor products from soybean oil. Studies on the enzymatic modification of soybean protein and the flavors derived therefrom have been initiated. This research is being conducted under a PL 480 grant.

C. Color, Texture, and Other Quality Factors

1. Flatulence factor of soybeans. In contract research at the University of Illinois, it was shown that fermentation of soybean oligosaccharides in the ileum and colon is apparently the explanation for flatulence caused by soybeans. Phenolic constituents of the soybean, such as genistin and chlorogenic and ferulic acids, appear to inhibit flatulence. Although sodium soy proteinate and sodium caseinate were effective in suppressing flatulence caused by soy flour, they were ineffective for navy bean flours. Soybean constituents and other special fractions used in this work were provided by the Northern Division.

2. Color reversion of soybean oil. In studies under a PL 480 grant to Sugiyama Chemical Research Institute, Tokyo, Japan, distinct progress on the cause and prevention of color reversion in soybean oil has been made. High-moisture beans have been associated with the cause of color reversion of soybean oil. The red color component which develops in the oil has been identified as tocored. The oxidative or enzymatic mechanism by which tocored develops is under investigation.

D. Microbiology and Toxicology

1. Aflatoxin investigations. Studies on toxins produced by molds are important to utilization of soybeans in foods. Results are reported under Area 3, subheading B-2.

2. U. S. soybeans for making tofu. In studies conducted under a PL 480 grant to the Japan Tofu Association, Tokyo, Japan, 26 varieties and experimental strains of U. S. soybeans were tested for use in making fresh tofu. Hawkeye proved to be the best in both laboratory experiments and pilot-scale trials.

3. Studies on miso and shoyu. These studies are being conducted by several foreign institutions under PL 480 grants.

At Bar-Ilan University, Ramat Gan, Israel, excellent miso-like products have been prepared from defatted soybean meals treated enzymatically prior to fermentation. The time of fermentation needed to make a satisfactory product by this procedure is about 7 weeks, as compared to the 3 to 6 months needed with conventional processing. Application has been made for a U. S. patent covering this development.

Investigators at the Central Miso Institute, Tokyo, Japan, tested 26 varieties and strains of soybeans for their suitability for making miso. Mandarin and Kanrich were judged superior.

Studies to find superior strains of the organism Saccharomyces rouxii for use in making miso and shoyu were continued at the Noda Institute for Scientific Research, Noda-shi, Chiba-ken, Japan. Good fermentative strains were found to exist in both mating types of the organism. However, those strains of the same mating type as NRRL Y-2547 were generally better with regard to flavor-producing abilities than those of the opposite mating type.

4. Chinese cheese (sufu). Chinese cheese is soft and difficult to retain in block shape. However, it can be well preserved for 3 months by heating it in a drying oven and sealing it in a polyvinyl chloride plastic bag which is then coated with paraffin. This work is being conducted under a PL 480 grant to the Institute of Chemistry, Academia Sinica, Taipei, Taiwan.

E. Technology - Process and Product Development

1. Full-fat soybean flour. In research supported by the Agency for International Development, engineers at the Northern Division have developed a simple hand process for producing full-fat soybean flour in villages and rural areas of developing countries. Soybeans are soaked overnight, boiled 10 to 15 minutes, air-dried, cracked, dehulled, and ground. All that this processing requires is an open fire and human muscle. Cracking, dehulling, and grinding are accomplished with simple, inexpensive, commercially available machines designed for manual operation.

Flours made by the hand process compared very favorably with commercial samples. Beverages prepared with the experimental flours showed good dispersion stability for 24 hours or longer. In a study of bacteriological and oxidative stability, samples of full-fat flour prepared by the hand process were stored 40 weeks at room temperature. Microbial counts remained

very low during this period. Taste panel evaluation showed no rancidity or off-flavors. Peroxide value at the end of the test was lower than that of soy flour made by a conventional process. Fifty pounds of the hand-process flour have been sent to Human Nutrition Research Division for evaluation as a component of various foods.

2. Quality of isolated protein for use in Israeli-type foods. Most of the research on the processing factors that affect yield, color, and nutritive value of isolated soy protein has been completed. Research on the use and functionality of isolated protein in foods is expanding and excellent progress has been made. Valuable information of direct application increasing the use of soybean protein products has been obtained. Some of the major U. S. soybean processors have expressed a great deal of interest in this project. These studies are being conducted under a PL 480 grant to the Israel Institute of Technology, Haifa, Israel.

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Chemical Composition and Physical Properties

Applebaum, S. W., Gestetner, B., and Birk, Y. (Hebrew University, Rehovot, Israel). 1965. Physiological aspects of host specificity in the Bruchidae. IV. Developmental incompatibility of soybeans for Callosobruchus. J. Insect Physiol. 11(6), pp. 611-616.*

Dolev, A., Rohwedder, W. K., and Dutton, H. J. 1966. Quantitative separation of methyl 9-hydroxystearate from methyl 13-hydroxystearate by column chromatography on silica gel. Lipids 1(3), pp. 231-233.

Gestetner, B., Birk, Y., and Bondi, A. (Hebrew University, Rehovot, Israel). 1964. Chemical composition of soybean saponins. Israel J. Chem. 2(5a), pp. 246-247.*

Gestetner, B., Birk, Y., and Bondi, A. (Hebrew University, Rehovot, Israel). 1965. The enzymatic breakdown of soybean saponins in the digestive tract of chicks, rats and mice. Israel J. Chem. 3, p. 88p.*

Ishaaya, I., and Birk, Y. (Hebrew University, Rehovot, Israel). 1965. Soybean saponins. IV. The effect of proteins on the inhibitory activity of soybean saponins on certain enzymes. J. Food Sci. 30(1), pp. 118-120.*

Kiribuchi, T., Chen, C. S., and Funahashi, S. (University of Tokyo, Tokyo, Japan). 1965. Systematic analysis of sterols in soybeans and other oil seeds. Agr. Biol. Chem. (Tokyo) 29(3), pp. 265-267.*

Rackis, J. J. 1965. Physiological properties of soybean trypsin inhibitors and their relationship to pancreatic hypertrophy and growth inhibition of rats. Federation Proc. 24(6), pp. 1488-1493.

Rackis, J. J., and Smith, A. K. 1965. Proteine di soia. Isolamento e proprieta. /Soybean proteins. Isolation and properties./ Minerva Dietol. 5(1), pp. 17-24.

Smith, A. K., Rackis, J. J., Isnardi, P., Cartter, J. L.,[1] and Krober, O. A.[1] ([1]U.S. Regional Soybean Laboratory, Urbana, Illinois). 1966. Nitrogen solubility index, isolated protein yield, and whey nitrogen content of several soybean strains. Cereal Chem. 43(2), pp. 261-270.

Willner, D.,[1] Gestetner, B.,[2] Lavie, D.,[1] Birk, Y.,[2] and Bondi, A.[2] ([1]Weizmann Institute of Science, Rehovot, Israel; [2]Hebrew University, Rehovot, Israel). 1964. Soya bean saponins. Part V. Soyasapogenol E. J. Chem. Soc. Suppl. 1, 1964, pp. 5885-5888.*

---

*Research supported by PL 480 funds.

Wolf, W. J., Sly, D. A., and Kwolek, W. F.[1] ([1]USDA Biometrical Serv., Peoria, Illinois). 1966. Carbohydrate content of soybean proteins. Cereal Chem. 43(1), pp. 80-94.

Flavor

Arai, S., Suzuki, H., Fujimaki, M., and Sakurai, Y. (University of Tokyo, Tokyo, Japan). 1966. Studies on flavor components in soybean. Part II. Phenolic acids in defatted soybean flour. Agr. Biol. Chem. (Tokyo) 30(4), pp. 364-369.*

Bailar, J. C., Jr., and Itatani, H. (University of Illinois, Urbana, Illinois). 1965. Hydridochlorobis(triphenylphosphine)platinum(II) and some related compounds. Inorg. Chem. 4(11), pp. 1618-1620.

Bailar, J. C., Jr., and Itatani, H. (University of Illinois, Urbana, Illinois). 1966. Catalytic hydrogenation of soybean oil methyl esters and some related compounds. J. Am. Oil Chemists' Soc. 43(6), pp. 337-341.

Butterfield, R. O., Dutton, H. J., and Scholfield, C. R. 1966. Counter double current distribution with continuous recovery for isolation of methyl linolenate. Anal. Chem. 38(1), pp. 86-88.

Chorney, W.,[1] Scully, N. J.,[1] and Dutton, H. J. ([1]Argonne National Laboratory, Argonne, Illinois). 1965. Radiation effects of carbon-14 and tritium on growth of soybeans. Radiation Botany 5(3), pp. 257-263.

Dutton, H. J., and Mounts, T. L. 1966. Desaturation of fatty acids in seeds of higher plants. J. Lipid Research 7(2), pp. 221-225.

Emken, E. A., Frankel, E. N., and Butterfield, R. O. 1966. Homogeneous catalytic hydrogenation of unsaturated fats: Metal acetylacetonates. J. Am. Oil Chemists' Soc. 43(1), pp. 14-18.

Evans, C. D., McConnell, D. G., Scholfield, C. R., and Dutton, H. J. 1966. Structure of unsaturated glycerides. Analysis by countercurrent distribution and lipase hydrolysis. J. Am. Oil Chemists' Soc. 43(6), pp. 345-349.

Evans, C. D., Moser, H. A., McConnell, D. G., Cowan, J. C., Cartter, J. L.,[1] and Collins, F. I.[1] ([1]U.S. Regional Soybean Laboratory, Urbana, Illinois). 1965. Flavor evaluation of natural soybean oils of high and low linolenate content. J. Am. Oil Chemists' Soc. 42(8), pp. 736-738.

Evans, C. D., McConnell, D. G., Frankel, E. N., and Cowan, J. C. 1965. Chromatographic studies on oxidative and thermal fatty acid dimers. J. Am. Oil Chemists' Soc. 42(9), pp. 764-770.

*Research supported by PL 480 funds.

Frankel, E. N., Emken, E. A., and Davison, V. L. 1965. Homogeneous hydrogenation of methyl linolenate catalyzed by iron pentacarbonyl. Formation of methyl octadecatrienoate-iron tricarbonyl complexes. J. Org. Chem. 30(8), pp. 2739-2745.

Frankel, E. N., Emken, E. A., and Davison, V. L. 1966. Isomerization of unsaturated fatty esters by iron pentacarbonyl. Preparation of iron tricarbonyl complexes of polyunsaturated fats. J. Am. Oil Chemists' Soc. 43(5), pp. 307-311.

Fujimaki, M., Arai, S., Kirigaya, N., and Sakurai, Y. (University of Tokyo, Tokyo, Japan). 1965. Studies on flavor components in soybean. Part I. Aliphatic carbonyl compounds. Agr. Biol. Chem. (Tokyo) 29(9), pp. 855-863.*

Hoffmann, R. L., Castle, F. J., and Evans, C. D. 1966. A molecular-still sample reservoir offering precise flow control. J. Am. Oil Chemists' Soc. 43(1), pp. 52-53.

Hoffmann, R. L., and Evans, C. D. 1966. Increased sensitivity of a thermal conductivity detector by cryostatic operation. J. Gas Chromatog. 4(5), p. 198.

Jones, E. P., Scholfield, C. R., Davison, V. L., and Dutton, H. J. 1965. Analyses of fatty acid isomers in two commercially hydrogenated soybean oils. J. Am. Oil Chemists' Soc. 42(8), pp. 727-730.

Koritala, S., and Dutton, H. J. 1965. Hydrogenation of linolenate. XII. Effect of solvents on selectivity. J. Am. Oil Chemists' Soc. 42(12), pp. 1150-1152.

Koritala, S., and Dutton, H. J. 1966. Selective hydrogenation of soybean oil with sodium borohydride-reduced catalysts. J. Am. Oil Chemists' Soc. 43(2), pp. 86-89.

List, G. R., Hoffmann, R. L., and Evans, C. D. 1965. Gas-solid chromatography of hydrocarbons on activated alumina. J. Am. Oil Chemists' Soc. 42(12), pp. 1058-1060.

Low, M. J. D., Bartner, P. L., and Krishnamurthy, R. (Rutgers, The State University, New Brunswick, New Jersey). 1965. The catalytic properties of vermiculite. J. Res. Inst. Catalysis, Hokkaido Univ., Sapporo, Japan 13(1), pp. 66-70.

Low, M. J. D., and Inoue, H. (Rutgers, The State University, New Brunswick, New Jersey). 1965. Infrared emission spectra of fatty acids on steel surfaces. Can. J. Chem. 43(7), pp. 2047-2051.

---

*Research supported by PL 480 funds.

McConnell, D. G., Evans, C. D., and Cowan, J. C. 1965. Solvent winterization of partially hydrogenated soybean oils. J. Am. Oil Chemists' Soc. 42(8), pp. 738-741.

Moser, H. A., Evans, C. D., Mustakas, G., and Cowan, J. C. 1965. Flavor and oxidative stability of some linolenate-containing oils. J. Am. Oil Chemists' Soc. 42(9), pp. 811-813.

Retcofsky, H. L.,[1] Frankel, E. N., and Gutowsky, H. S.[2] ([1]Pittsburgh Coal Research Center, Bureau of Mines, U.S. Dept. Interior, Pittsburgh, Pennsylvania; [2]University of Illinois, Urbana, Illinois). 1966. Carbon-13 magnetic resonance of diene-iron tricarbonyl complexes. J. Am. Chem. Soc. 88(12), pp. 2710-2712.

Scholfield, C. R., Butterfield, R. O., and Dutton, H. J. 1966. Preparation of pure methyl esters by counter double current distribution. Lipids 1(3), pp. 163-165.

Scholfield, C. R., and Emken, E. A. 1966. Isolation of methyl cis-15-octadecenoate by chromatography on a silver-treated macroreticular exchange resin. Lipids 1(3), pp. 235-236.

Vioque, A., Gutierrez, R., Albi, M. A., and Nosti, N. (Institute of Fats and Their Derivatives, Seville, Spain). 1965. Trace elements in edible fats. IX. Influence of demetalization on the oxidative and flavor stabilities of soybean oil. J. Am. Oil Chemists' Soc. 42(4), pp. 344-345.*

Vioque, A., Gutierrez, R., Albi, M. A., and Nosti, N. (Institute of Fats and Their Derivatives, Seville, Spain). 1965. Elementos trazas en grasas comestibles. XII. Nuevos ensayos sobre "desmetalización" de aceites de soja. /Trace elements in edible fats. XII. New experiments on demetalizing soybean oil./ Grasas y Aceites 16(6), pp. 269-277.*

Color, Texture and Other Quality Factors

Steggerda, F. R.,[1] Richards, E. A.,[1] and Rackis, J. J. ([1]University of Illinois, Urbana, Illinois). 1966. Effects of various soybean products on flatulence in the adult man. Proc. Soc. Exp. Biol. Med. 121, pp. 1235-1239.

Microbiology and Toxicology

Hesseltine, C. W., and Martinelli, A., Jr. Jan. 11, 1966. Improved methods for producing tempeh. U. S. Patent 3,228,773.

---

*Research supported by PL 480 funds.

Ilany-Feigenbaum, J. (Bar-Ilan University, Ramat-Gan, Israel). 1965. The proteolytic enzymes of Japanese koji and taka-diastase. J. Food Sci. 30(1), pp. 148-150.*

Technology - Process and Product Development

Eldridge, A. C., and Nash, A. M. Nov. 16, 1965. Process of producing soybean proteinate. U. S. Patent 3,218,307.

RELATED PUBLICATIONS OF STATE EXPERIMENT STATIONS

Chemical Composition and Physical Properties

Anderson, P. M., and Schultze, M. O. 1965. Interaction of S-(1,2-dichlorovinyl)-L-cysteine with proteins. Arch. Biochem. Biophys. 109(3), pp. 615-621. (Minn.)

Anderson, P. M., and Schultze, M. O. 1965. Cleavage of S-(1,2-dichlorovinyl)-L-cysteine by an enzyme of bovine origin. Arch. Biochem. Biophys. 111(3), pp. 593-602. (Minn.)

Bernhard, R. A., and Niemann, C. 1965. A dilatometric investigation of the alpha-chymotrypsin-catalyzed hydrolysis of nicotinyl-L-tryptophanamide. Arch. Biochem. Biophys. 110(1), pp. 195-199. (Calif.)

Foster, J. F., Sogami, M., Petersen, H. A., and Leonard, W. J., Jr. 1965. The microheterogeneity of plasma albumins. I. Critical evidence for and description of the microheterogeneity model. J. Biol. Chem. 240, pp. 2495-2502. (Ind.)

Newton, W. A., Morino, Y., and Snell, E. E. 1965. Properties of crystalline tryptophanase. J. Biol. Chem. 240, pp. 1211-1218. (Calif.)

Petersen, H. A., and Foster, J. F. 1965. The microheterogeneity of plasma albumins. II. Preparation and solubility properties of subfractions. J. Biol. Chem. 240, pp. 2503-2507. (Ind.)

Pomeranz, Y. 1965. Evaluation of factors affecting the determination of nitrogen in soya products by the biuret and orange-G dye-binding methods. J. Food Sci. 30(2), pp. 307-311. (Kans.)

Roberts, R. C., and Briggs, D. R. 1965. Isolation and characterization of the 7S component of soybean globulins. Cereal Chem. 42(1), pp. 71-85. (Minn.)

---

*Research supported by PL 480 funds.

Saari, J. C., and Schultze, M. O. 1965. Cleavage of S-(1,2-dichlorovinyl)-L-cysteine by Escherichia coli B. Arch. Biochem. Biophys. 109(3), pp. 595-602. (Minn.)

Silveira, A., Jr., Masuda, Y., and Chang, S. S. 1965. Chemical reactions involved in the catalytic hydrogenation of oils. II. Identification of some volatile by-products. J. Am. Oil Chemists' Soc. 42(2), pp. 85-86. (N. J.)

Stein, J. M. 1965. Differential thermal analysis of protein denaturation in solution. Arch. Biochem. Biophys. 112(3), pp. 599-604. (Pa.)

Travis, J., and Liener, I. E. 1965. The crystallization and partial characterization of porcine trypsin. J. Biol. Chem. 240, p. 1962. (Minn.)

Travis, J., and Liener, I. E. 1965. The sequence of amino acids in the vicinity of the active serine residue of porcine trypsin. J. Biol. Chem. 240, pp. 1967-1973. (Minn.)

Williams, E. J., and Laskowski, M., Jr. 1965. A method for distinguishing between complete and partial exposure of tryptophyls in proteins. J. Biol. Chem. 240, pp. 3580-3584. (Ind.)

Wong, R. C., and Liener, I. E. 1965. Amino acid sequence involving the reactive thiol group of ficin. Biochem. Biophys. Res. Commun. 17, p. 470. (Minn.)

Flavor

Wyatt, C. J., and Day, E. A. 1965. A simplified and precise flavor evaluation procedure for determining oxidative rancidity in vegetable oils. J. Am. Oil Chemists' Soc. 42(8), pp. 734-736. (Oreg.)

Hill, F. D., and Hammond, E. G. 1965. Studies on the flavor of autoxidized soybean oil. J. Am. Oil Chemists' Soc. 42(12), pp. 1148-1150. (Iowa)

Color, Texture and Other Quality Factors

Hackler, L. R., Van Buren, J. P., Steinkraus, K. H., El Rawi, I., and Hand, D. B. 1965. Effect of heat treatment on nutritive value of soymilk protein fed to weanling rats. J. Food Sci. 30(4), pp. 723-728. (N. Y.)

Shane, J. F., et al. 1965. Results of Kentucky soybean variety performance tests (with observations on herbicide, rate of planting, and fertilizer tests), 1964. Ky. Agr. Exp. Sta. Progr. Rep. 146, pp. 1-10. (Ky.)

Microbiology and Toxicology

Borchers, R. 1965. Antibiotics and the anti-threonine effect of raw soybean meal. Life Sciences 4, pp. 1835-1837. (Nebr.)

Finkenstadt, W. R., and Laskowski, M., Jr. 1965. Peptide bond cleavage on trypsin-trypsin inhibitor complex formation. J. Biol. Chem. 240, pp. 962-963. (Ind.)

Gould, N. R., and Liener, I. E. 1965. Reaction of ficin with diisopropylphosphorofluoridate. Evidence for a contaminating inhibitor. Biochemistry 4(1), pp. 90-98. (Minn.)

Technology - Process and Product Development

Steinkraus, K. H., Van Buren, J. P., Hackler, L. R., and Hand, D. B. 1965. A pilot-plant process for the production of dehydrated tempeh. Food Technol. 19(1), pp. 63-68. (N. Y.)

Stillings, B. R., and Hackler, L. R. 1965. Amino acid studies on the effect of fermentation time and heat-processing of tempeh. J. Food Sci. 30(6), pp. 1043-1048. (N. Y.)

PEANUT UTILIZATION - FOOD
Northern Utilization Research and Development Division, ARS

Problem. Peanuts constitute a major cash crop in the Southern States and are in surplus. Because of their high price, domestically produced peanuts are used primarily (currently about 63 percent of the crop) in foods such as peanut butter, confections, bakery goods, and roasted and salted nuts. A critical problem in the utilization of peanuts, which has recently been made more clearly evident, is the sporadic contamination of peanuts by toxin-producing strains of common molds. The possibility of toxins entering foods intended for human consumption, as well as feedstuffs, is of the utmost concern. Intensified research is therefore urgently needed on the isolation, identification, evaluation, control, and inactivation or removal of mold toxins, such as aflatoxin, which may develop in peanuts and processed peanut products. New-type food products and improvement in the quality and uniformity of existing products are needed to increase consumer acceptance and extend markets for peanuts; the average per capita consumption has been rather stable since World War II. The increased trend toward mechanical harvesting has necessitated the use of artificial means for curing and drying peanuts, with the result that processed peanuts and peanut products do not always possess the same desirable flavor and physical properties as peanuts which have been cured slowly in the field. Information is needed as to the physical and chemical characteristics of those chemical constituents in peanuts which affect flavor, aroma, and other important properties of the processed products, as a basis for developing new or improved products and processing procedures. Fundamental studies of peanut proteins and associated materials could similarly lead to the development of new concepts and new uses.

USDA AND COOPERATIVE PROGRAM

The Department has a continuing long-term program involving organic chemists, biochemists, analytical chemists, microbiologists, and chemical engineers engaged in both basic and applied studies on peanuts and peanut products to increase consumer acceptance and extend markets for peanuts.

Research to develop basic information on the chemical composition and properties of peanuts, its constituents, and processed peanut products is carried out at New Orleans, Louisiana. As a part of the Seed Protein Pioneering Research Laboratory's research on various seed proteins, fundamental investigations of peanut proteins and associated materials are conducted to form the basis for developing new concepts and perhaps new uses for peanuts and peanut proteins.

Research on the flavor of peanuts and their processed products is also conducted at New Orleans, Louisiana. One phase of this research includes investigations of the lipid or lipid-soluble constituents of peanuts and processed peanut products involved in the genesis of peanut flavor and

aroma. The Crops Research Division of ARS, the Consumer and Marketing Service, and several State Experiment Stations cooperate in the research by providing samples of peanuts of known variety and history. Additional research on flavor is being carried out under contract at the Agricultural Experiment Station, Oklahoma State University, Stillwater, Oklahoma, on a study of the relation of the carbohydrate, amino acid and protein components of the peanut to the formation of flavor and aroma during roasting.

Certain aspects of microbiology and toxicology as they relate to peanuts and their processed products are being investigated at New Orleans, Louisiana. An important line of such research is the isolation, identification, evaluation and control of fungi and toxic fungal metabolites, particularly aflatoxins, that may develop in these products.Related research is concerned with the development of economically feasible methods for the inactivation or removal of aflatoxins from contaminated peanuts and peanut products to permit their utilization in foods (and feeds). Cooperation is maintained with the Crops Research Division, ARS, Market Quality Research Division, ARS, State Experiment Stations, the Pharmacology Laboratory of WU, the Food and Drug Administration, industry, and nutritionists in USDA, at universities and elsewhere, in connection with this research. The problem of mycotoxins is also receiving attention in contract research at the Agricultural Experiment Station, Auburn University, Auburn, Alabama, on a study of the limiting environmental conditions for the elaboration of mycotoxins in peanuts; and at the Agricultural Experiment Station, Texas A&M University, College Station, Texas, to develop information relating processing methods, preprocessing history, distribution of immature, mature and germinating peanuts, and external conditions such as mold incidence as they affect consumer-use properties of processed peanut products.

Research on technology for the development of new and improved processes and products is being conducted at New Orleans, Louisiana. One project is concerned with the development of low-fat peanuts having acceptable peanut flavor and texture characteristics. Informal cooperation is maintained with peanut suppliers and processors, and with nutritionists and home economists for evaluation of experimental products as required. Other research, supported by the Agency for International Development, involves a study of the preparation of peanut flours and their derived products for human consumption in developing countries. Cooperation is maintained with UNICEF for arranging nutritional evaluations of experimental products in developing countries, and with the Human Nutrition Research Division, ARS, for evaluating certain of the products. Additional research on process and product development is being carried out under contract at the Agricultural Experiment Station, Auburn University, Auburn, Alabama, on the development of peanut products for use in preparation and fortification of processed and convenience foods; and at the Agricultural Experiment Station, Oklahoma State University, Stillwater, Oklahoma, on a study of sterilizing or inactivating treatments in conjunction with artificial drying and curing of peanuts to develop processing conditions needed for producing mycotoxin-free roasted peanut products of optimum quality.

Other research on chemical composition and physical properties is in progress under a grant of P. L. 480 funds to the following foreign institution: The University of Granada, Granada, Spain, for an investigation of the rate of reaction of protein with carbohydrates in peanuts, to provide information leading to improved peanut products, thereby increasing the utilization of this commodity (project duration - 3 years).

The Federal in-house scientific research effort in this area totals 11.6 scientific man-years. Of this number, 2.8 are devoted to chemical composition and physical properties, 1.4 to flavor, 3.3 to microbiology and toxicology, 4.1 to technology--process and product development. The contract research involves an additional 3.3 scientific man-years, 1.0 on flavor, 1.2 on microbiology and toxicology, and 1.1 on technology--process and product development. P. L. 480 research involves one grant on chemical composition and physical properties.

The only line of work to be terminated during the year was contract research on the isolation, identification, and characterization of flavor and aroma components of processed peanut products (under Flavor).

PROGRAM OF STATE EXPERIMENT STATIONS

A total of 8.0 scientific man-years is devoted to this area of research.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Chemical Composition and Physical Properties

1. Chemical, Physical, and Biological Properties and Structural Factors of the Proteins. In pioneering research conducted in the Seed Protein Pioneering Research Laboratory, the ultrastructure of seeds, including peanuts, methods of enzyme and protein research, and protein synthesis in seeds are being investigated.

For several years a program has been underway here to develop techniques for staining seeds for electron microscopy in nonaqueous media. The reasons for omitting aqueous fixation was that such might create artifacts similar to those which arise at the onset of germination and would not enable an interpretation to be made of what exactly is happening in the resting seed. In previous years, there were reported descriptions of ultrastructure based on fixation with permanganate. The program has now been completed by development of techniques of osmium fixation as applied to dry cottonseed. Such a procedure has enriched the amount of detail made visible by the electron microscope. For example, it shows that the hyaloplasm contains numerous microtubules. These structures are still the subject of speculation as to their function but it is generally thought that they have a transport function in the cell. By this staining technique it has also been possible to see ribosomes in resting cottonseed.

Aleurone grains, the repository of the storage protein in seeds, have been isolated from peanut cotyledons by ultrasonic treatment of homogenates. That these were pure was demonstrated by observation with the electron microscope. No cytoplasmic protein was present; arachin was predominant. The total proteins of the embryo of the peanut contained mostly alpha-conarachin and very little arachin. This might suggest that there are two types of aleurone particles present in the peanut: one of which predominates in the cotyledon and another one in the embryo.

Electron microscopy of oilseeds shows structures which appear to be similar to those identified in the literature as spherosomes. The spherosomes of germinating peanuts were isolated and purified and shown to have the same structure in the isolated form as shown in intact tissue by electron microscopy. The spherosomes contain about 98% triglycerides and account for all of the lipid in the cotyledon. It can be calculated that the content of protein and phospholipid is just sufficient to account for a membrane surrounding the spherosomes. The spherosomes do not contain certain enzymes which are associated with fat metabolism. More about this is reported in a later section.

Globoids can be seen in ultrastructure as nonstainable spherical sections within the aleurone grains. These globoids have now been isolated from cottonseed homogenates. They contain 14% phosphorus, 1% of which is inorganic phosphorus and phosphorus-bound lipid; the remainder is phytin phosphorus. Globoids contain small amounts of protein which has a different amino acid composition than the protein of the entire aleurone grains. On the basis of the composition of phytic acid, these globoids can be said to contain 80% phytic acid.

Some of the properties of castor lipase were described in previous reports. These include the facts that it is present in the resting castor bean, is particulate-bound, and contains a lipid cofactor. There now can be added the finding that a soluble, low-molecular weight peptide can be removed from the lipase simply by incubation at acid pH. This removal is reversible; considerable progress has been made in purifying the peptide activator. Since the activator has a low-molecular weight, an examination was made of the ability of castor allergens to activate the apolipase. Crude castor allergens do indeed activate the apolipase. Work is continuing to determine whether there is any relationship between allergens and this peptide portion of the castor lipase enzyme.

The presence of an ATP phosphoinositol phosphotransferase, was demonstrated in the germinating peanut. This enzyme catalyzes the phosphorylation of ADP forming ATP and utilizes phytate as the phosphoryl donor. There is, however, nucleotidediphosphate transferase (adenylate kinase) activity in the peanut tissue. Hence, it is not clear how much of the formation of ATP is due to the phytic acid acting as a phosphagen and how much is due to the kinase. A rapid paper electrophoresis method of separating and identifying each of the phosphate esters of inositol has been developed.

The entire question of the possibility of phytic acid acting as a phosphagen was investigated from another viewpoint by the use of calorimetry to determine the enthalpy of hydrolysis of each of the inositol phosphate esters. The values thus far obtained for the diphosphate and higher phosphate esters of inositol show that these esters have low phosphoryl transfer potential and would not therefore be likely to act as phosphagens.

In an earlier section it was stated that studies were made of the enzyme activity of spherosome fractions. They were tested particularly for lipase and for coenzyme A acylase activity. These activities are not associated with spherosomes: the acylase activity is in the soluble fraction and the lipase activity is in a particulate fraction that sediments at the same rate as mitochondria. The lipase found in this fraction differs from the lipase in the resting seed in that the former is inhibited by inorganic phosphate.

Progress has been made in fractionation techniques for seed proteins. This includes improvements in preparative electrophoresis on polyacrylamide gel. Two gels are now being used superimposed one on the other--3% over 5%. Progress has also been made in applying Sephadex fractionation on the seed proteins. Thus, on infrequent occasions it has been possible to isolate a fraction by gel electrophoresis which is pure by criteria of chromatography, gel electrophoresis, and ultracentrifugation. Efforts are now being made to study the conditions under which this is effected and obtain enough of the material for further study.

The proteins of the peanut have been studied by immunoelectrophoresis. It has been found by this technique that purification of arachin or conarachin either by DEAE chromatography or gel electrophoresis changes the mobility of the major fractions. That these are still identical with the original fractions was demonstrated by this technique.

In a previous report it was demonstrated that cottonseed cotyledon shows a difference between the axial portion and distal portion in terms of synthesis of the lipase. Gibberellic acid can promote synthesis of lipase in the distal portion; aflatoxin was shown to inhibit this synthesis. A further study of the effect of concentration of aflatoxin on this property indicates that in low concentrations aflatoxin stimulates the synthesis of proteins in the distal portion; in this respect it has an effect similar to gibberellic acid. Aflatoxin also promotes synthesis of the systems involved in development of chlorophyll pigments; this, too, is a property shown by gibberellic acid. Aflatoxin, however, does not affect elongation of the leaf cells; this property is shown by gibberellic acid. (SU P 1).

B. Flavor

1. Identification of Constituents and Factors Influencing Flavor and Aroma of Processed Products. Investigations of lipid and lipid-soluble constituents of peanuts and their processed products to expand the utilization of

food-grade peanuts have been continued. Attention has recently been directed to the phosphatides and those compounds contributing to the characteristic odor of roasted peanuts. Use of two different solvent systems showed that oils extracted from dry-roasted peanuts have a strong peanut aroma, whereas only a faint aroma is detected in the residual meal; the trace of aroma remaining in the condensate after the solvent is removed is not characteristic of freshly roasted peanuts. Application of a large amount of oil (about 400 mg.) per gram of the silicic acid on chromatographic columns, followed by elution with chloroform-methanol (4:1), revealed that the bulk of the peanut odor is in the predominately cephalin fraction. On careful concentration in vacuo a strong peanutlike aroma occurs in the residue, but a burnt, or over-roasted note is intensified. Over-concentration results in loss of nearly all aroma, which can be detected in the distillate. Since the components responsible for aroma and flavor of roasted peanuts are moderately volatile and are also extractable with the oils, these techniques may have value in relating peanut components to flavor and ultimately to preparing a concentrate suitable for flavoring foods or confections. (S4 1-109(Rev.)).

In completed contract research conducted by Evans Research and Development Corporation, extraction of ground, roasted peanuts with an organic solvent (methanol), and separation of that extract into acidic, phenolic, basic, and neutral fractions, was found to be the most useful method of obtaining flavor and aroma constituents. Each of the different fractions thus obtained had a distinct aroma, usually suggestive of peanuts. Qualitative and quantitative differences noted among the acid fractions of the three varieties of peanuts examined (Virginia, Runner, and Starr) indicate the possibility of genetic control of the flavor of roasted peanuts. The acids identified were acetic, propionic, isobutyric, butyric, isovaleric, valeric, hexanoic, heptanoic, decanoic, lauric, and myristic. Phenylacetic acid was identified, and an unknown acid (possibly a dihydroxynaphthaleneacetic acid) that had no aroma but a bitter taste was isolated. The presence of several phenols was noted in the phenolic fractions, but none were positively identified. Lactones were isolated in small quantities from this fraction. Infrared spectroscopy suggested that these are aliphatic, six-membered lactones. Hexanal, 2, 4-decadienal, and β-sitosterol were isolated from the neutral fractions. Also isolated was a 2, 4-dinitrophenylhydrazone of a compound which appeared to be 2-oxooctanal. Sensory panel evaluations of the peanut extracts showed that a peanutlike aroma was consistently maintained in portions of the neutral fraction. The unique fractionation scheme devised by the contractor may be of value in the utilization of these flavor and aroma components to improve processed peanut products. (S4 1-106(C)).

Other contract work related to the previous project is being conducted by the Agricultural Experiment Station, Oklahoma State University of Agriculture and Applied Science. The relationship of the carbohydrate, amino acid, and protein components of the peanut to the formation of flavor and aroma during roasting is being investigated for shelled and unshelled Argentine variety peanuts cured under four conditions (windrow, 90° F.,

105° F., and 120° F.) and stored under three conditions (ambient, 36° F., and 70° F.). Although the 1964 and 1965 growing seasons were different, each year there were about 66.2% mature and intermediate fruits when the windrow-cured samples were dug. Flavor preference for cured, roasted peanuts before storage was for windrow-cured samples and decreased as the curing temperature increased. Since agreement between replications of analyses on aleurone grains appeared more consistent than those from precursor fractions, these more reproducible analyses may lead to an objective test for evaluating peanut flavor. Consistent differences in ninhydrin (an indication of free amino acids) and pentose sugar values of aleurone grains were noted between peanuts stored shelled and unshelled but these differences could not be correlated with flavor differences. However, it does appear that off-flavor precursors develop during curing rather than during storage, and this lead will be further clarified by planned analyses of selected soluble nitrogen fractions.(S4 1-119(C)).

C. Microbiology and Toxicology

1. Investigation of Occurrence, Determination, and Properties of Fungi and Toxic Fungal Metabolites That May Develop in Peanuts and Their Processed Products. Several lines of research are directed toward solving problems connected with fungi and their toxic metabolites that may occur in peanuts and their processed products. One project, conducted under contract to the Agricultural Experiment Station, Auburn University, concerns the limiting environmental conditions for the elaboration of mycotoxins in peanuts during storage and processing. Both relative humidity and temperature are significant factors influencing aflatoxin elaboration on nonliving peanuts. Limiting relative humidity (RH) for aflatoxin production by A. flavus was found to be 85.5 ± 0.5% RH for 21 days' storage at 30° C. Although equilibrium moisture content of immature kernels was significantly higher than that of sound mature kernels and unshelled nuts, aflatoxin production was essentially equivalent in all cases. Mechanically damaged kernels produced the highest aflatoxin levels. At RH levels of 97-99%, aflatoxins were produced during storage at the relatively low temperatures of 13-20° C. Temperature has pronounced effect on the ratio of aflatoxin B_1 to aflatoxin G_1, low temperature favoring high G_1 and higher temperatures favoring high B_1 production. The limiting maximum temperature at 97-99% RH was 41.5° C. ± 1.5° C.; at 43° C., fungus growth and sporulation were heavy, but no aflatoxins were produced. In chemically defined liquid media, aflatoxins were produced with glucose, sucrose, or fructose as carbon sources. Complex organic nitrogen sources such as yeast extract and peptone produced higher aflatoxin levels than purified amino acids. Little or no aflatoxin was produced when zinc, iron, or magnesium was omitted from the medium, whereas manganese seemed to reduce aflatoxin yields at all concentrations. Plans include the extension of this investigation to freshly dug living peanuts. (S4 1-121(C)).

Much of the work on a related project, in-house research on fungi and toxic fungal metabolites, has recently been devoted to cottonseed. However, the objective densitometer measurements of aflatoxins described in that section

can also be used for purified extracts of peanut products. Research under this project on the processing of peanuts has shown that under standard conditions of alkali refining, all traces of aflatoxins are removed from contaminated peanut oils. Thus, even if contaminated kernels are processed, any toxin carried into the crude oil will be removed during refining. It has also been shown that roasting portions of individual aflatoxin-contaminated peanut cotyledons resulted in an average reduction of 68% in total aflatoxins, with reduction of B_1 greater than B_2. Color is not a good criterion for detecting aflatoxin-contaminated cotyledons either before or after roasting. Work on the effect of roasting on appearance and aflatoxin content of contaminated peanuts will be continued. (S4 1-116).

Peanuts of known history with respect to growing, harvesting, and curing conditions are being studied in contract research conducted by the Agricultural Experiment Station, Texas A&M University; this information will be used in the development of processing methods to produce high-quality peanut products that are free of mycotoxins. Although no data on aflatoxins were reported during this period, additional organoleptic data have been obtained. Peanuts were oil-roasted for 20 minutes at temperatures of 320°, 340°, and 360° F. The 340° product was preferred. Irrigation significantly improved flavor quality, whereas fumigation of the soil did not. Large peanuts, which are retained on a size 17 screen, were of higher flavor quality than smaller kernels. Oil-roasted peanuts processed from bag-dried fruits were preferred to those prepared from field-dried. Oven-dried kernels yielded the lowest flavor scores, but differences were small, as was the case with dry-roasted peanuts. These findings may assist in selecting raw peanuts for processing into edible products of highest quality: larger size, grown under irrigation and cured in bags at ambient temperatures after threshing immediately following harvest. (S4 1-120(C)).

Exploratory work on the inactivation or removal of aflatoxins from contaminated peanuts and their products has resulted in advances that may ultimately permit their utilization in foods and feeds. Treatment of peanut meal with ammonia or with aqueous acetone may offer a practical means of reducing its aflatoxin content. Peanut meal containing approximately 3100 ppb of B_1 was adjusted to 15% moisture and treated with anhydrous ammonia under 40 psig pressure for about 16 min. at a maximum temperature of 178° F. The aflatoxin content was reduced to 17 ppb. Aqueous acetone (5 to 10% water) extraction of peanut meal containing 60 ppb B_1 reduced the content 80-85%. In contrast, treatment of peanut meals with amines was less effective than with the previously mentioned agents. Peanut meal containing 60 ppb B_1 was adjusted to 15% moisture, treated with methylamine, and stored in sealed containers at elevated temperatures. After 24 hrs. at 38° C., there was only slight reduction in aflatoxin content; after 3 hrs. at 93° C. aflatoxin was reduced 75%. Plans include the investigation of various chemical treatments on both a laboratory and pilot-plant scale to develop practical methods for inactivating aflatoxin. (S4 1-133).

D. Technology -- Process and Product Development

1. Peanut Flours and Derived Products for Human Consumption in Developing Countries. Peanut meals of high quality, judged by chemical analyses, have been prepared under a project supported by the Agency for International Development (AID). A high-quality, low-fat peanut flour was prepared for evaluation by Human Nutrition Research Division (HN); results were good to excellent in such diverse preparations as beverages for babies, cookies, breads, chapatis, curry, garbanzo stew, pancakes, and noodles. Peanut meals and flours have also been shipped to Canada, England, and Harvard University for various investigations of their nutritional values. Plans include development of the simplest and most practical processes for relatively small plants in developing countries to use in making highest quality peanut flour; continued improvement of the flour; and evaluation of medium-fat peanut flours for food use. (SU-0-0-3(AID)).

2. New Processed Products, Including Partially Defatted Peanut Products. Based on information developed at SU, commercialization of the partially defatted peanut product has been realized. One company is now producing and market testing, on a large scale, low-fat Spanish peanuts in several areas in the South. The product is sold in 10¢ flexible opaque bags. Another company is now offering pressed Virginia peanuts in sufficient quantities for development purposes or for use in preparing low-fat peanuts for the retail market. Many other companies are developing and evaluating low-fat peanut products, and several are planning market tests soon. New and delicious spice-coated low-fat peanut products have been developed. New information on the low-fat peanut product development is continually being made available to industry. Cooperative investigations with processing equipment manufacturers to upscale the process for commercial application continued. Pilot-plant runs conducted with two manufacturers show that: (1) commercial fluid-bed dryers are suitable for the production of dry-roasted low-fat peanuts, and (2) further development work is needed before infrared drying equipment can be used for this purpose. Shelf-life studies are being conducted on products produced by these processes. Large-scale investigations with commercial cage presses (with 20" diameters and 24"-deep material-holding chambers) show less oil removal than that obtained for the same pressures in laboratory and pilot-plant size presses with cake thickness of 3". Bench and pilot-plant scale work to investigate and improve specific operations of the process also continued. Tests with peanuts having low-moisture content (1-4%), expansion with a puffing gun, and pressing but not expanding in hot water did not give satisfactory results. However, preliminary work showed that L-lysine monohydrochloride can be added internally to low-fat peanuts during expansion; practical methods for this addition and evaluation of the resulting products will be studied, as well as other improvements in properties and processing. (S4 1-126).

Studies continued on preparation of defatted peanut flours, meals, and grits, as specified in the research contract awarded to the Agricultural Experiment Station at Auburn University. Screw pressing operation was

improved by use of radiant heat, but not by reducing screw speed. Results of lye blanching tests appeared very promising. Exposure to lye for only 20 seconds removed 100% of the skins with little separation of kernel halves. Blanched peanuts had a bright glossy appearance. The problem of grinding to a flour fineness was solved by use of a recently acquired special mill. Methods were tested for solvent extraction of partially defatted peanuts and for detection of hexane residue. Products were prepared for recipe tests. Shelf-life studies were begun on several products in glass and in saran. Work was initiated on use of peanut products in ice cream and confections. A combination of peanuts and applesauce, drum dried and used in a mix, has produced a good product. Raw peanut products were found to be definitely unacceptable because of their undesirable flavor and aroma, which remained despite additions of various flavorings. Meals and grits in the lower oil levels were unacceptable because they retain a hard mealy or gritty texture. Meals and grits at all oil levels were unacceptable, in products such as soups, gruels, dips, ice cream, and puddings because of their gritty texture. Meals at three higher oil levels can be used in some baked products, such as cookies and the "heavier" cakes, e.g., nut breads. Plans include the continued preparation of peanut products at different oil levels and the evaluation of their properties. (S4 1-118(C)).

3. Methods Developed for Inactivating or Removing Aflatoxin from Contaminated Peanut Kernels. The development of processing conditions to produce optimum-quality, mycotoxin-free roasted peanuts is the objective of a contract awarded to the Agricultural Experiment Station, Oklahoma State University. Three preliminary areas are presently being investigated. In the first area, field experiments were conducted with the Argentine variety of Spanish-type peanuts. A. flavus spores were inoculated onto freshly dug peanuts; variables studied included presence or absence of plastic coverings, treatment with chemical inhibitors, and two field incubation periods. Samples of freshly dug peanuts were stored at 20° F. All field readings--regardless of inoculation, plastic coverings, or chemical treatment--were negative for observed pod surface fungus development at both incubation times. The cold storage samples are being used in laboratory incubation studies at 30° C. in saturated humidity atmosphere. In the second area, work was initiated on the design of a laboratory vacuum drying system. In the third area, means of analyses for aflatoxin have been set up and will be used on selected samples from the field trials. (S4 1-132(C)).

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Chemical Composition and Physical Properties

Altschul, A. M., Yatsu, Lawrence Y., Ory, Robert L., and Engleman, E. Mark. 1966. Seed proteins. Ann. Rev. Plant Physiol. 17, pp. 113-136.

Boudreaux, H. B. (LSU, Baton Rouge, La.) and Frampton, V. L. 1965. The status of the problem of hemostasis and peanuts. Proc. Intern. Soc. Rehabilitation Disabled, 9th World Congr., Copenhagen, Denmark, 1963, pp. 281-284.

Brown, H. D. (Research Associate), Neucere, N. J., Altschul, A. M., and Evans, W. J. 1965. Activity patterns of purified ATPase from Arachis hypogaea. Life Sci. 4, pp. 1439-1447.

Lee, Louise S., Morris, Nelle J., and Frampton, Vernon L. 1965. Peanut flour constituents. Cyclic imino acid derivative from peanut flour. J. Agr. Food Chem. 13, pp. 309-311.

St. Angelo, Allen J., Conkerton, Edith J., Dechary, Joseph M., and Altschul, Aaron M. 1966. Modification of edestin with N-carboxy-d,l-alanine anhydride. Biochim. Biophys. Acta 121, pp. 181-183.

Microbiology and Toxicology

Cucullu, Alva F., Lee, Louise S., Mayne, Ruth Y., and Goldblatt, L. A. 1966. Determination of aflatoxins in individual peanuts and peanut sections. J. Am. Oil Chemists' Soc. 43, pp. 89-92.

Goldblatt, Leo A. [Publ. 1965]. Removal of aflatoxin from peanut products with acetone-hexane-water solvent. Intern. Symp. "Mycotoxins in Foodstuffs," Cambridge, Mass., 1964, pp. 261-263.

Goldblatt, L. A. and Robertson, J. A., Jr. 1965. Extraction of aflatoxin from groundnut meal with acetone-hexane-water azeotrope. Intern. Biodeterioration Bull. 1(1), pp. 41-42.

Technology--Process and Product Development

Vix, H. L. E., Spadaro, James J., Pominski, Joseph, and Pearce, H. M., Jr. 1965. Mechanically squeeze out 80% of oil without distorting shape of low-calorie peanuts. Food Process.Marketing 26(9), pp. 80-83.

General

Altschul, Aaron M. 1965. Edible seed protein concentrates: their role in control of malnutrition. Israel J. Med. Sci. 1(3), pp. 471-479.

Altschul, Aaron M. 1965. A look at the world protein situation. Oil Mill Gaz. 70(6), pp. 14-20. Also: Cotton Gin Oil Mill Press 66(24), pp. 7, 26-28; Soybean Dig. 26(8), pp. 15, 16, 19-22.

Altschul, Aaron M. 1965. Research accomplishments with seed proteins for human food. Proc. Ann. Meeting Agr. Res. Inst. 14, pp. 41-50.

RELATED PUBLICATIONS OF STATE EXPERIMENT STATIONS

Chemical Composition and Physical Properties

Mason, M. E., Johnson, B., and Hamming, M. C. 1965. Mass spectral analysis of carbonyls regenerated from their 2,4-dinitro-phenyl-hydrazones. An extension of the procedure of Ralls. Anal. Chem. 37, pp. 760-761.(Okla.)

Flavor

Pattee, H. E., Beasley, E. O., and Singleton, J. A. 1965. Isolation and identification of volatile components from high-temperature-cured off-flavor peanuts. J. Food Sci. 30(3), pp. 388-392. (North Carolina)

Technology--Process and Product Development

Roberson, Sara and Woodroof, J. G. 1965. Formula for commercial peanut butter ice cream. Ga. Agr. Res. 6(3), p. 11. (Georgia)

Roberson, Sara and Woodroof, J. G. 1965. Commercial peanut butter ice cream formula developed. Peanut J. and Nut World 44(4), pp. 10-11. (Georgia)

Woodroof, J. G. 1965. Peanut butter ice cream. Ice Cream Trade Journal 61(5), p. 37. (Georgia)

Young, Clyde T. and Holley, K. T. 1965. Comparison of peanut varieties in storage and roasting. Ga. Agr. Exp. Sta. Tech. Bull. (n.s.) 41. (Georgia)

CRAMBE UTILIZATION - INDUSTRIAL PRODUCTS
Northern Utilization Research and Development Division, ARS

Problem. Crambe, a new oilseed crop commercialized in 1965, is the first plant included in the research program on new crops to achieve this status. Crambe seed oil is rich in erucic acid. Several industrial uses already existed for erucic acid as well as for imported rape seed oil, which formerly was the only source of this acid. However, the greatest impetus to commercialization of crambe was perhaps the discovery that crambe oil performed better than any other known material as a lubricant in continuous casting of steel. This situation emphasizes the importance of finding the most advantageous specific applications that can contribute to utilization of any new crop in its own right.

To insure optimum development of crambe as a new economic crop, possible markets for crambe oil and erucic acid must be explored and those with the greatest industrial potential must be identified and made effective. This goal can be reached through a program of basic and applied research that will provide more information on the chemical and physical properties of crambe oil, its component fatty acids, and their chemical derivatives. When promising leads to possible industrial applications are found, product and process development research will be needed to evaluate the potential and to provide facts and data essential for commercial adoption of crambe oil products in new end uses.

USDA AND COOPERATIVE PROGRAMS

The Department conducts a continuing, long-range program of research involving analytical and organic chemists and chemical engineers engaged in basic and applied research on industrial utilization of crambe oil. The objectives of the work are to obtain new information on reactions of crambe oil and its component fatty acids and to use this information to develop new products for use by the chemical and other industries.

The Federal scientific effort for research on industrial utilization of crambe totals 5.2 scientist man-years. Of this number, 4.0 are devoted to chemical and physical investigations to improve products and 1.2 to technology - process and product development.

Research at Peoria, Illinois, on chemical and physical investigations to improve products (4.0 scientist man-years) is concerned with chemical modification of crambe oil and its component fatty acids, especially erucic acid, to obtain chemical intermediates or derivatives having desirable properties for industrial use.

Research on technology - process and product development involves a research contract (1.2 scientist man-years) with Southern Research Institute, Birmingham, Alabama, for studies on preparation and evaluation of polyamide resins derived from crambe oil.

PROGRAM OF STATE EXPERIMENT STATIONS

A combined total of 1.0 scientist man-year is devoted to research on industrial and feed uses of crambe.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Chemical and Physical Investigations to Improve Products

1. Chemical derivatives from crambe oil. Homopolymerization of vinyl 2-methylpentyl brassylate (VMB) and its copolymerization with vinyl chloride were successfully carried out. Conversions were 75 percent or greater. The results showed that VMB acted as an internal plasticizer for polyvinyl chloride (PVC). A copolymer containing 30 percent VMB had greatest flexibility at low temperatures. Evaluation (conducted at the Eastern Division) of bis-(cyclohexylmethyl) brassylate showed that it had plasticizing properties for PVC intermediate to that of cyclohexyl brassylate and mixed brassylates of cyclohexyl and 2-ethylhexyl alcohols.

Under an informal agreement, Emery Industries, Inc., Cincinnati, Ohio, ozonized crambe free fatty acids and sent 317 pounds of the dibasic acid product to the Northern Division. It contained 31 percent azelaic, 47 percent brassylic, 15 percent other dibasic, and 7 percent monobasic acids.

A series of 12 mixed diesters of mixed dibasic acids (azelaic and brassylic acids from ozonization of crambe acids) was prepared for further plasticizer evaluation at the Eastern Division. In evaluations at the Southern Division, a series of disubstituted amides of erucic acid and mixed crambe acids were found to be more efficient plasticizers for PVC than dioctyl phthalate. The amides from mixed crambe acids displayed more restricted compatibility in comparison to the corresponding erucic acid derivatives.

An improved laboratory method for ozonolysis of erucic acid, in which reaction products are converted to methyl esters, resulted in recovery of 95 percent pure dimethyl brassylate in 88-percent yields. The best previous recovery based on distillation and crystallization of free brassylic acid was 70 percent of theory.

Several reaction products of brassylic acid and ethylene oxide were equal to commercial surfactants used in emulsion polymerization of vinyl chloride.

B. Technology - Process and Product Development

1. Polyamide resins from erucic acid. In contract research at Southern Research Institute, all synthetic steps from erucic acid to nylon-1313 have been placed on a satisfactory preparative basis. Overall yield is 51 percent of theory. Several samples of nylon-1313 were prepared with molecular weights ranging from 12,000 to 47,000. Southern Research Institute has successfully prepared 10 pounds of nylon-1313 for evaluation. Preliminary tests showed that nylon-1313 can be either extrusion or compression molded; that it can be melt-spun into monofilaments and cold drawn; and that it has very low moisture absorption. A procedure was devised for facile conversion of brassylic dinitrile, a principal intermediate in preparing nylon-1313, to the nylon 13 monomer, 13-aminotridecanoic acid.

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Chemical and Physical Investigations to Improve Products

Earle, F. R., Peters, J. E., Wolff, I. A., and White, G. A.[1] ([1]New Crops Research Branch, Beltsville, Maryland). 1966. Compositional differences among crambe samples and between seed components. J. Am. Oil Chemists' Soc. 43(5), pp. 330-333.

Miwa, T. K. 1965. Dimpled-bottomed flasks for high-speed magnetic stirring. Chemist-Analyst 54(4), pp. 121-122.

Miwa, T. K., Kwolek, W. F.,[1] and Wolff, I. A. ([1]USDA Biometrical Serv., Peoria, Illinois). 1966. Quantitative determination of unsaturation in oils by using an automatic-titrating hydrogenator. Lipids 1(2), pp. 152-157.

RELATED PUBLICATIONS OF STATE EXPERIMENT STATIONS

See next area.

CRAMBE UTILIZATION - FEEDS
Northern Utilization Research and Development Division, ARS

Problem. The economic value to the farmer and to industry of any oilseed crop is much greater if the meal left after extraction of the oil can be utilized as a palatable and nutritious feed for animals. Crambe, a new and only recently commercialized oilseed crop developed under the new crops research program, yields a meal that, on the basis of amino acid analysis, should be an excellent feed product. However, as is true for other oilseed meals, such as soybean meal, suitable processing is needed to realize fully the anticipated nutritional qualities and to insure maximum acceptability to different types of animals. Needed research includes isolation and characterization of components of crambe meal that are important to nutritional value, flavor, and other essential qualities of a feed. The fate of these components during processing must be investigated in order to learn how to preserve desired components and eliminate or minimize the effects of deleterious ones. Finally, engineering studies are required to translate laboratory findings into economical and practical processes for industrial use.

USDA AND COOPERATIVE PROGRAMS

The Department maintains a continuing, long-range program of basic and applied research involving analytical and organic chemists and chemical engineers engaged in study of the components of crambe meal and in development of effective processes for converting crambe seed to oil and palatable, nutritious meal for animal feed.

The Federal scientific effort for research on feed uses of crambe totals 7.1 scientist man-years. Of this number, 5.3 are devoted to chemical composition and physical properties and 1.8 to technology - process and product development.

Research on chemical composition and physical properties is conducted at Peoria, Illinois, and is concerned with studies on components of crambe meal such as enzymes, other nitrogenous components, pigments, flavor principles, etc.

Research on technology - process and product development, also conducted at Peoria, Illinois, is devoted to engineering studies on processing crambe seed to oil and palatable, nutritious meal.

PROGRAM OF STATE EXPERIMENT STATIONS

A combined total of 1.0 scientist man-year is devoted to research on industrial and feed uses of crambe.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Chemical Composition and Physical Properties

1. Crambe enzymes. Two types of crambe enzyme were isolated. One fraction (insoluble) converts the thioglucoside epi-progoitrin (EPG) to (R)-goitrin; the other (soluble) converts EPG to nitriles. The soluble enzyme fraction, after dialysis, converted EPG to goitrin, and the insoluble fraction at pH 5-6 in the presence of 0.01 M ferrous ion produced nitriles. Addition of EDTA did not prevent nitrile formation in autolysis of whole meal, but added mercaptoethanol, added ferrous ion, or exclusion of oxygen suppressed goitrin formation.

2. Conversion products from epi-progoitrin (EPG). Further study of EPG degradation products formed upon autolysis of crambe meal established the presence of two previously unobserved products in addition to (R)-goitrin and 1-cyano-2-hydroxy-3-butene. These were identified as episulfides, specifically the isomeric 3,4-epithio-1-cyano-2(S)-hydroxy-butanes differing only in configuration at C-3. Chemical treatments of the disilver salt of EPG produced (R)-goitrin and 1-cyano-2-hydroxy-3-butene.

3. Toxicity tests and feeding studies. Toxic properties of epi-progoitrin were demonstrated by feeding studies with rats. Growth was almost normal but pathological changes in the liver and thyroid occurred. Tests with rats and mice showed that the crude "cyano" fraction from autolyzed whole meal had greater toxicity than synthetic 1-cyano-2-hydroxy-3-butene. Purified sinapine bisulfate had no effect on growth rate or feed consumption by rats. Detoxified crambe meals were prepared by autolysis and extraction with aqueous acetone. When fed as the sole protein source to rats, they had protein efficiency ratios of 2.55 and 2.75 (casein, 2.50; soy meal, 2.15). Steaming one of these crambe meals reduced the ratio to 1.51. These studies were conducted with the cooperation of the Pharmacology Laboratory at the Western Division.

B. Technology - Process and Product Development

1. Processing crambe to oil and meal. Sodium carbonate (soda ash) and sodium hydroxide were found to be promising additives for detoxification of crambe meal. Use of 2 percent soda ash with full-fat or defatted crambe meal combined with a moist-steam cooking operation proved superior to ammoniation with respect to apparent detoxification and simplicity of operation.

Comparative palatability of crambe meals prepared at the Northern Division and treated with soda ash, sodium hydroxide, and ammonia was determined in cattle feeding trials at the University of Nebraska. Best palatability, nearly equal to that of soybean meal, was observed for meals treated with soda ash. Ammonia-treated meals also gave good results.

During November 1965, Pacific Vegetable Oil Company--with cooperation and supervision by two Northern Division engineers--processed 740,000 pounds of crambe seed (without dehulling), using the Northern Division soda ash process as closely as equipment permitted. Several sets of conditions were evaluated while the plant was on-stream to determine optimum conditions for processing the larger part of the run. The desolventized meal after extraction contained less than 1 percent oil and about 29 percent protein. Several tons of meal, including a quantity not treated with soda ash, were provided to the Northern Division for use in feeding trials with cattle and other animals. The remainder of the meal and all of the oil were disposed of by PVO through their normal sales channels.

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Chemical Composition and Physical Properties

Daxenbichler, M. E., VanEtten, C. H., and Wolff, I. A. 1966. (S)- and (R)-1-cyano-2-hydroxy-3-butene from myrosinase hydrolysis of epi-progoitrin and progoitrin. Biochemistry 5(2), pp. 692-697.

Tookey, H. L., VanEtten, C. H., Peters, J. E., and Wolff, I. A. 1965. Evaluation of enzyme-modified, solvent-extracted crambe seed meal by chemical analyses and rat feeding. Cereal Chem. 42(6), pp. 507-514.

Technology - Process and Product Development

Kirk, L. D., Mustakas, G. C., and Griffin, E. L., Jr. 1966. Crambe seed processing: Filtration-extraction on a bench scale. J. Am. Oil Chemists' Soc. 43(5), pp. 334-336.

McGhee, J. E., Kirk, L. D., and Mustakas, G. C. 1965. Methods for determining thioglucosides in Crambe abyssinica. J. Am. Oil Chemists' Soc. 42(10), pp. 889-891.

Mustakas, G. C., Kopas, G.,[1] and Robinson, N.[1] ([1]Pacific Vegetable Oil Corp., San Francisco, California). 1965. Prepress-solvent extraction of crambe: First commercial trial run of new oilseed. J. Am. Oil Chemists' Soc. 42(10), pp. 550A, 552A, 554A, 594A.

RELATED PUBLICATIONS OF STATE EXPERIMENT STATIONS

(Publications on industrial and feed utilization of crambe)

Chemical Composition and Physical Properties

Anon. 1965. A look at some new crops for Iowa. Iowa Farm Science, FS-1143. (Iowa)

SAFFLOWER, CASTOR, AND OTHER WESTERN OILSEEDS UTILIZATION - INDUSTRIAL PRODUCTS

Northern Utilization Research and Development Division, ARS

Problem. Cash crops for diversification and rotation programs need to be increased, particularly in the cotton-producing areas of the western states. A crop with potential for these programs is safflower, which is emerging as an important source of industrial and edible oil, as well as of seed meal that may find uses in foods and feeds. Basic information is needed on the composition of the oil, and this requires development of adequate analytical methodology. Rapid and accurate analytical methods are also needed to control and improve the processing of oil for industrial applications. Safflower oil is particularly valued because of its non-yellowing qualities when used in surface coatings. Breeding research has yielded varieties of safflower with wide variation in fatty acid contents, pointing to the opportunity of growing specific crops for specific applications.

Castor also can provide the diversification that is needed in western growing areas. Utilization research is pointing the way to improved products such as lubricants and foamed polyurethane plastics. Domestic production of castor is so limited that much of our United States requirement must be imported, and large stocks are held by the government as a strategic reserve. Control of allergenic and toxic components of castor meal would make available a high-protein product for feed and food uses. Better utilization of domestic castor seed oil meal could increase the total value of the domestic crop and be an incentive to increase the acreage and thus reduce our dependence on imports. Safflower, on the other hand, has become a significant item of export with 240,000 tons of safflower seed exported in calendar year 1964. This export was essentially all to hard-currency customers, so the export of safflower and the decreased import of castor would both benefit our unfavorable international trade balance. Basic and applied research is needed to provide improved processes for and products from safflower, castor and other western oilseeds.

USDA AND COOPERATIVE PROGRAM

In the Western Utilization Research and Development Division, both basic and applied research are conducted on castor and safflower seed at the Division headquarters at Albany, California; under contract in Tucson, Arizona, Minneapolis, Minnesota, and Fargo, North Dakota; and by P.L. 480 grant funds in India. Studies are conducted on the composition of castor and safflower oils and on new products therefrom. New analytical and preparative techniques are developed.

The Federal program of research in this area totals 6.3 scientist man-years, including contract research equivalent to approximately 1.5 scientist man-years per year. Of this total 1.9 are assigned to chemical composition,

physical properties and structure; 2.1 to chemical and physical investigations to improve products; and 2.3 to technology--process and product development. In addition, three grants are sponsored under P.L. 480.

PROGRAM OF STATE EXPERIMENT STATIONS

A total of 11 scientist man-years is devoted to Areas 10, 11, and 12.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Chemical Composition, Physical Properties and Structure

1. Oil and Oilseed Components. The absolute configurations of dimorphecolic, lesquerolic, and densipolic acids, derivatives of Dimorphotheca and Lesquerella species, were determined. Highly purified samples of the methyl esters of these long-chain unsaturated acids and their saturated derivatives were examined by spectropolarimetry. A D-configuration was established for all the derivatives. Confirmation of configurational assignments was obtained by using the reduced form of the hydroxy acids, because we have observed that unsaturated acids of identical configuration give different data. The absolute configuration of lesquerolic acid was unequivocally established by its synthesis (in six steps) from ricinoleic acid of known configuration.

The far ultraviolet spectra of a series of cis and trans, mono- and poly-substituted unsaturated fatty acid esters were examined spectrophotometrically. Data obtained showed some inconsistencies with earlier results. Spectral data are useful to establish existence of such acids in unknown mixtures and thereby to characterize chemical reactions that occur in the processing of oils and synthesis of useful industrial compounds.

Analysis of current commercial safflower seed types shows that they are composed of about 40% hull, 37% oil, and 23% meal. Experimental varieties exist with hull percentages ranging from 59 to 18 and inversely varying oil and meal percentages. In safflowers of high linoleic acid content, fatty acid composition is quite constant. In genetic studies selections with equal oleic and linoleic acid contents, with high oleic and low linoleic acid content, and with relatively high stearic acid contents are being obtained. The high degree of genetic control of fatty acid content offers a great potential for improving safflower varieties. Varieties will probably be bred for a specific fatty acid content depending upon the industrial products they are destined for.

B. Chemical and Physical Investigations to Improve Products

1. Oil Derivatives. Improved methods reported previously were used to prepare large quantities of methyl 12-ketostearate. High conversion and yield of pure product were obtained with low levels of commercial copper chromite catalyst. By using distilled commercial methyl 12-hydroxystearate, 96% conversion was obtained. A sample of pure N,N-dimethyl 12-acryloxystearamide

was provided for our contractor at the University of Arizona for polymerization studies. Methyl 12-ketostearate and 12-ketostearamide were sent on request to Armour Industrial Chemical Company for evaluation. Methyl 12-ketostearate was sent on request to the Baker Castor Oil Company.

Improved methods of alkali fusion have been developed and new phosphorus derivatives prepared for evaluation. In contract research at the University of Arizona good progress has been made on polymerization and evaluation studies on monomers derived from oilseeds. Evaluation of such new polymers and copolymers for possible use in rubber modification, coating applications, and adhesive compounds should provide more industrial outlets for oilseeds.

Keto derivatives and other potentially useful compounds, including polymerizable monomers, were prepared. Improved methods were developed for preparing omega-hydroxy acids by alkaline fusion. The starting material is a hydroxy unsaturated acid, such as ricinoleic acid from castor or lesquerolic acid from Lesquerella species. Transformation of hydroxy fatty acid esters to keto fatty acid esters were monitored successfully by using gas liquid chromatography. This was made possible by converting the hydroxy compounds to their trifluoroacetyl or trimethylsilyl derivatives.

Investigations of the preparation of polymerizable monomers from castor oil hydroxy fatty acids are supported by P.L. 480 grant funds to the Regional Research Laboratory in Hyderabad, India. Methods for preparing acryloxy and methacryloxy monomers from castor oil hydroxy fatty acids were considerably improved to get higher yields and better quality products. Preparation, purification, and characterization of six monomers obtainable from castor oil have been described. A considerable number of monomers were sent to the Western Utilization Research and Development Division for examination and evaluation in polymerization systems.

Another P.L. 480 research grant to the same institution is used for investigating selected hydroxylated derivatives of linseed and safflower oils. The project is under the joint supervision of the Western and Northern Divisions. Three chemical routes have been followed for introducing monohydroxy functions into unsaturated oils. To sulfate safflower oil, 86% sulfuric acid was used. The subsequent hydrolysis of sulfate to hydroxyl groups was accomplished by using acidified barium chloride solution. Only about half the unsaturation lost was accountable as new hydroxyl groups. Partially epoxidized unsaturated esters or oils were converted to the corresponding monohydroxy products by hydrogenation in ethanol medium at a high pressure. Safflower oil was peroxidized by bubbling air at 0° C. for 40 hours under ultraviolet irradiation. Subsequent reduction of the hydroperoxide to hydroxy groups was easily achieved by a number of procedures. Catalytic hydrogenation yielded the highest hydroxyl value. Build-up of hydroxyl by peroxidation to a low value, reduction to hydroxyl, and further peroxidation led to thick dark unsatisfactory products.

C. Technology--Process and Product Development

1. Castor-Based Products. New castor oil derivatives that may be useful in flame-resistant foams were made by incorporating chlorine or bromine. Castor oil-based components with improved storage stability are being developed, with special attention being given to flame resistance which is especially needed in structural uses of rigid urethane foams. A series of rigid foams was prepared from homopolymers and copolymers of vinyl 12-hydroxystearates. Properties of these foams were generally inferior to those of similar foams prepared from castor oil or hydrogenated castor oil. The resistance of several castor oil-based urethane foams to attack by fungi and other microorganisms is under investigation. No loss of strength or visible signs of attack were evident in castor oil-based urethane foams after 6 months' burial in moist earth.

An investigation of continuous production and evaluation of castor-based urethane foams is being conducted by contract with the Archer-Daniels-Midland Company. Castor formulations provided by the Western Utilization Research and Development Division were used for preliminary evaluations. Flame retardants, synthetic polyols to blend with castor oil, different isocyanates in the urethane formulation, silicone surfactants, and castor oils of different grades are included in these tests. Two commercially available isocyanates were used to prepare acceptable foams from castor-based polyols with equivalent weights as high as 120. Prepolymer systems or crude isocyanates require castor-based polyols with equivalent weights in the 50-100 range for adequate foams. The initial screening results conducted under this contract corroborate much of the batch-operation laboratory work we have done.

Highly efficient methods have been developed for converting low-cost hydrogenated castor oil esters to ketostearate esters which have unique physical and chemical properties that are useful in permanent-type automotive lubricants and mold-release compounds. Inexpensive catalysts rapidly convert the castor esters to ketostearates--processing costs are estimated at only a few cents a pound. A yearly market for several million pounds of ketostearates in lubricant application is anticipated, and now that ketostearates can be prepared inexpensively, exploratory investigations can be launched to find new industrial uses for this type of compound.

Castor-based and polyether-based rigid urethane foams have been compared as to the effect of aging on their thermal conductivity. Uncut samples of both types of foam (representing foam-in-place applications) maintained equivalent low thermal conductivities throughout test periods of 6 to 12 months. Common practice, however, is to cut samples for testing. With such samples, thermal conductivities increased at different rates. The initial increase in thermal conductivity of castor oil-based foams was greater than in polyether-based foams, because the rate of diffusion of air into the foam cells was higher. However, tests with uncut samples are the more realistic, so we conclude that castor-based foams are not inferior for many of the most important uses for polyurethanes.

By a method developed here, controlled alkali-fusion of castor oil has yielded predominantly omega-hydroxy acid rather than sebacic acid. This method is under investigation by two large producers of fatty derivatives. They undoubtedly plan scale-ups to produce this unique chemical for large-volume use in plastics and biodegradable detergents, and in the manufacture of other chemicals.

2. Lesquerella and Dimorphotheca. Evaluation of Lesquerella and Dimorphotheca as possible replacement crops has been discontinued. However, contract research at North Dakota State University on surface coatings from hydroxy unsaturated oils continued into this reporting period and studies of the properties of dehydrated Lesquerella and Dimorphotheca oil have been completed. Fatty acids of Dimorphotheca oil contain up to 60% of 9-hydroxy-trans-10-trans-12-octadecadienoic acid. The oil itself dries poorly in the presence of conventional dryers. Addition of nonconjugated cis triglycerides, for example 5% of linseed oil, bring about a market improvement in the drying properties of this oil. The hydroxyl group of dimorphecolic acid was used advantageously in preparation of film-forming compositions. Coatings with excellent properties have been prepared by reacting the oil with several mono- and poly-isocyanates. The combination of the oil modified with rosin esters by means of the poly-functional isocyanates was studied. Both mono- and poly-isocyanates and modifying resins had a significant effect on the physical properties of films.

PUBLICATIONS - USDA AND COOPERATIVE PROGRAMS

Chemical Composition, Physical Properties and Structure

Binder, R. G., Goldblatt, L. A., and Applewhite, T. H. 1965. Measurements on isolated double-bond systems. Ultraviolet absorption spectra of fatty acid esters. J. Org. Chem. 30(7), pp. 2371-2376.

Binder, R. G., and Lee, A. 1966. Hydroxymonoenoic acids of Lesquerella desipila seed oil. J. Org. Chem. 31, pp. 1477-1479.

Knowles, R. E., Goldblatt, L. A., Kohler, G. O., Toy, S. J., and Haun, J. R. 1965. Oilseed composition of two species of Dimorphotheca grown at five locations in the United States. Econ. Botany 19(3), pp. 262-266.

Chemical and Physical Investigations to Improve Products

Applewhite, Thomas H. 1965. The synthesis of (+)-14 D-hydroxy-cis-11-eicosenoic (Lesquerolic) acid. Tetrahedron Letters 38, pp. 3391-3395.

Diamond, M. J., Binder, R. G., and Applewhite, T. H. 1965. Alkaline cleavage of hydroxy unsaturated fatty acids. I. Ricinoleic acid and lesquerolic acid. J. Am. Oil Chem. Soc. 42(10), pp. 882-884.

Freedman, Bernard, and Applewhite, T. H. 1966. Dehydrogenation of methyl 12-hydroxystearate to methyl 12-ketostearate with Raney nickel. J. Am. Oil Chem. Soc. 43(3), pp. 125-127.

Subbarao, R., Rao, Venkateswara, and Achaya, K. T. 1966. Protection of unsaturation during heterogeneous catalytic hydrogenation of alphatic epoxy to hydroxy groups. Tetrahedron Letters, No. 4, pp. 379-381.1/

Technology - Process and Product Development

Lyon, C. K., Garrett, V. H., Black, D. R., Applewhite, T. H., and Goldblatt, L. A. 1965. Thermal conductivity of castor oil-based rigid urethane foams. Amer. Chem. Soc. Div. of Organic Coatings & Pastics Chem. 24(2), pp. 99-102, 1964; also I&EC Prod. Res. & Development 4(3), pp. 189-191.

Marvel, C. S., Griffith, J. H., Comp, J. L., Applewhite, T. H., and Goldblatt, L. A. 1965. Preparation and polymerization of vinyl esters of chloro- and hydroxystearic and eicosanoic acids. J. Polymer Sci. 3A(8), pp. 2991-3001.

RELATED PUBLICATIONS OF STATE EXPERIMENT STATIONS

Chemical Composition, Physical Properties and Structure

Anon. 1965. Forage crop varieties for Montana. Montana Agr. Expt. Sta. Circ. 242, 69 pp. Mont.

Anon. 1965. Baco, a new combine sesame. Texas Agr. Expt. Sta. Leaflet 644, pp. 1-2. Texas.

Brewbaker, J. L., and Hylin, J. W. 1965. Variations in mimosine content among Leucaena species and related Mimosaceae. Crop Sci. 9(4), pp. 348-349. Hawaii.

Corley, W. L. 1965. Some preliminary evaluations of okra plant introductions. Georgia Agr. Expt. Sta. Bull. N. S. 145. Ga.

Creel, G. C., Ericson, J. E., and Schulz-Schaeffer, J. 1965. Biosystematic investigations in the genus Agropyron Baertn. III. Serological, morphological, and cytological comparison of species within the crested wheatgrass complex (section Agropyron). Crop Sci. 5, pp. 316-320. Mont.

Dam, R., Lee, S., Fry, P. C., and Fox, H. 1965. Utilization of algae as a protein source for humans. J. Nutr. 86, pp. 376-382. Nebr.

Goering, K. J., Eslick, R. F., and Brelsford, D. L. 1965. A search for high erucic acid containing oils in the Cruciferae. Econ. Botany 19, pp. 251-256. Mont.

Goering, K. J., Eslick, R. F., and Brelsford, D. L. 1965. The composition of the oil of Berteroa incana and the potential value of its seed as a cash crop for Montana. Econ. Botany 19, pp. 44-45. Mont.

Killinger, G. B. 1965. Kenaf, Hibiscus cannabinus L. and Erucastrum abyssinica as potential industrial crops for the South. Proceedings, Assoc. Southern Agr. Workers Inc., pp. 54-55. Fla.

Knowles, P. F. 1965. Variability in oleic and linoleic acid contents of safflower oil. Econ. Botany 19, pp. 53-62. Calif.

Knowles, P. F., et al. 1965. Safflower. California Agr. Expt. Sta. Circ. 532, pp. 1-51. Calif.

Mann, H. O., and Haus, T. E. 1965. Safflower testing. Colorado Agr. Expt. Sta. Progress Report 174, pp. 1-2. Colo.

Martin, J. A. 1965. Gourds of all types for garden and market. South Carolina Agr. Expt. Sta. Res. Ser. 64. S. C.

Rogers, Marlin N. 1965. Chemical growth retardants for poinsettias. Missouri State Flor. News 26(4), pp. 3-8. Mo.

SAFFLOWER, CASTOR, AND OTHER WESTERN OILSEEDS UTILIZATION - FEED
Northern Utilization Research and Development Division, ARS

Problem. Cash crops for diversification and rotation programs need to be increased, particularly in cotton-producing areas of the western states. A crop with potential for these programs is safflower, which is emerging as an important source of seed meal having great possibilities for food and feed use, in addition to its importance as a source of edible and industrial oil. Basic information is needed on the composition of meals and oil, and this in turn requires development of adequate analytical methodology. Rapid and accurate analytical methods are also needed to control and improve the processing of meals and oils for feed and other uses. Thin-hulled varieties of safflower, being developed through breeding research, will provide greater yields of seed meal and oil. We are cooperating with industry, state and federal plant breeders to develop analytical methodology needed to guide these studies.

Castor also can provide the diversification needed in western growing areas. Control of allergenic and toxic components of castor meal would make available a high-protein product for feed and food uses. We import much of the castor oil required for industrial use, but better utilization of domestic castor seed oil meal would increase the total value of the domestic crop and be an incentive to increase the acreage and reduce our dependence on imports. Safflower, on the other hand, has become a significant item of export with 240,000 tons of safflower seed exported in calendar year 1964. This export was essentially all to hard-currency customers, so the export of safflower and the decreased import of castor would both benefit our unfavorable international trade balance. Basic and applied research is needed to provide improved processes for the products from safflower, castor and other western oilseeds.

USDA AND COOPERATIVE PROGRAM

In the Western Utilization Research and Development Division, research on developing new and improved feeds from safflower, castor, and other western oilseeds is conducted at Albany, California. The Federal program of research in this area is equivalent to about 1.6 scientist man-years per year.

PROGRAM OF STATE EXPERIMENT STATIONS

A total of 11 scientist man-years is devoted to Areas 10, 11, and 12.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Technology--Process and Product Development

1. Improved Feeds from Oilseed Meals. Information and processes are being developed to produce a low-fiber safflower meal and to determine its feed

value. Decortication and hull removal prior to oil extraction from safflower seeds was used to prepare 40 kilograms of meal for evaluation in animal rations. Initial studies of commercial and laboratory-processed meals indicate that commercial operations have reduced the solubility of protein. Chick-feeding tests show that safflower meal contains little if any deleterious components. (See paragraph 10-B-2.)

Primary utilization problems in feeds, then, revolve around the low metabolizable energy of safflower meals. The hulls are relatively indigestible, and the methionine and lysine content of safflower protein is low. When meals are supplemented with an energy source and with lysine and methionine, growth rates obtained in broiler chicks were outstanding. When low-fiber meals can be produced, perhaps by decortication, larger markets can be expected for the meal in poultry and swine rations. Potential markets for improved safflower meal exist in the United States and abroad.

Castor meal can be deallergenated with lime, under the following process conditions: temperature, at least 120° C., preferably 140° C.; time, 1 hour or more; liquid-to-solids ratio, 3; lime concentration, at least 8% by weight. The high lime content limits the usefulness of the product, hence further studies are being made with sodium hydroxide, alone and in combination with lime. At present, the lime treatment can be considered as only a stopgap measure; cost reduction is needed. New work on a high-pressure steam process for castor meal deallergenation is promising. It is evident that steam pressures in excess of 80 lbs. per sq. in. will be required to avoid long processing times.

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Technology--Process and Product Development

Layton, Laurence L. 1965. Passive transfer of human atopic allergies into lemurs, lorises, pottos, and galagos: possible primate-ordinal specificity of acceptance of passive sensitization of human atopic reagin. J. Allergy 36(6):523-31.

SAFFLOWER, CASTOR, AND OTHER WESTERN OILSEEDS UTILIZATION - FOOD
Northern Utilization Research and Development Division

Problem. Cash crops for diversification and rotation programs need to be increased, particularly in cotton-producing areas of the western states. A crop with potential for these programs is safflower, which is emerging as an important source of edible and industrial oil as well as edible seed meal for both food and feed use. Basic information is needed on the composition of the oil and meal and, to obtain this information, adequate analytical methodology must be developed. Rapid and accurate analytical methods are also needed to control and improve the processing of oil and meal.

The high percentage of linoleic acid (essential fatty acid) in safflower oil is a feature that is leading to its rapidly expanding use as a food oil. And breeding research is producing varieties with other advantages. One new variety is very high in oleic acid, providing an oil of unusual stability against oxidation in food products and in cooking. New thin-hulled varieties give greater yields of oil and seed meal, but flavor and color problems exist in the most promising thin-hulled varieties so far developed. Utilization research is required to remove the odoriferous substances and pigments so that a light-colored bland oil is obtained.

Safflower has become a significant item of export, with 240,000 tons of safflower seed exported in calendar year 1964. This export was essentially all to hard-currency customers, so it benefits our unfavorable international trade balance.

Castor also can provide the diversification that is needed in western growing areas. But we anticipate only limited food use of it, although the oil has been used in Asia for centuries for cooking purposes.

Basic and applied research is needed to provide improved processes for and products from safflower, castor, and other western oilseeds.

USDA AND COOPERATIVE PROGRAM

In the Western Utilization Research and Development Division, both basic and applied research are conducted on safflower and castor seed at the Division headquarters at Albany, California and under contract at Tucson, Arizona. Basic compositional studies on oilseed meals are concerned with the resolution of their water-soluble proteins and determination of their nutrient properties for food. Studies are conducted on the composition and stabilities of safflower oils. New analytical techniques also are being developed.

The Federal program of research in this area totals 2.7 scientist man-years, including contract research equivalent to approximately 0.5 scientist

man years per year. Of this total 0.5 are assigned to chemical composition and physical properties, and 2.2 to technology--process and product development.

PROGRAM OF STATE EXPERIMENT STATIONS

A total of 11 scientist man-years is devoted to Areas 10, 11, and 12.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Chemical Composition and Physical Properties

1. Antioxidants of Safflower Oil. Under a contract at the University of Arizona in Tucson, naturally occurring antioxidants in safflower oil are being separated, purified, and characterized. Moisture, volatiles, oil, and free fatty acid contents; peroxide value; and autoxidation induction period were determined for a series of representative safflower oils. Induction period for autoxidation was affected by light, so methods had to be developed to eliminate the effects of incident light on the reaction mixtures. Methods were also developed to isolate and measure the amounts of tocopherols present in oil. Commercial oil samples from various processing stages were examined for relative stability. In total, 28 samples of high-linoleic safflower oil have been investigated. Their autoxidation induction periods ranged from 163 hours for refined, bleached, deodorized, commercial oil to 696 hours for an oil from an experimental variety. Compositional data are incomplete, so any correlation that may exist between tocopherol content and stability of the various samples has not been established. Removal of the non-saponifiable fraction from an oil reduced its stability, but adding the non-saponifiable material from one of the stable oils to a less stable oil did not significantly increase the stability. It is proposed that natural antioxidants are destroyed or eliminated during saponification.

A high oleic safflower variety (UC-1) developed in the breeding program at the University of California at Davis was found to have an autoxidation induction period greater than 2,000 hours in the series of tests conducted at the University of Arizona.

B. Technology--Process and Product Development

1. Oxidative Stability of Safflower Oils. High-oleic safflower oil was evaluated for oxidative stability under high-temperature conditions, and the results were compared with those obtained with ordinary safflower oil and other vegetable oils. Crude high-oleic oil was superior to the other oils tested in that less polymerization occurred. Refined high-oleic oil was slightly inferior to a commercial blend of hydrogenated vegetable oils. Since hydrogenation costs could be avoided, however, high-oleic safflower oil, with excellent stability under conditions used in commercial food frying, can become a major cooking oil once its production is increased. The high-oleic oil is liquid at refrigerator temperatures, so it could be handled

easily from drums or bulk storage, and thus handling cost would be less for large commercial users. Several very large companies have eagerly sought information and samples of this remarkable vegetable oil.

The odor problem associated with some thin-hulled varieties continues under investigation. Hull oil obtained by solvent extraction can be further extracted with dilute base to remove color and odor. Color and odor concentrates were obtained by column chromatography from hull oil in order to study chemical composition. Data on odor- and color-causing constituents will be valuable to growers, breeders, and processors working on new promising safflower varieties.

2. Safflower Seed Meal. Partially decorticated safflower seed meals ranging from 42 to 50% protein and an experimental undecorticated meal from a new thin-hulled type of safflower seed were subjected to comprehensive chemical analysis and biological evaluation using chicks. Samples were analyzed for proximate constituents, cellulose, lignin, pentosans, water-soluble vitamins, and amino acids. Methionine and lysine were the only amino acids that are relatively deficient in the meals. When these were added and when adequate energy was supplied to compensate for the high-fiber content, safflower meals produced growth rates superior to those produced by a corn-soya ration. This indicates that safflower meals contain little if any of the deleterious components found in legume seeds, and so could provide a new and highly desirable protein source for poultry and swine. Such use will depend on economic factors involving supplementation with fat to supply the energy deficit and with lysine and methionine. Improved methods of decortication, especially as applied to the thin-hulled varieties, should enhance the potentialities for safflower meal in animal feeds and open the way for development of low-cost human foods from safflower. Removal of the disagreeable flavor in thin-hulled safflower seed from low-fiber, low-fat meal was accomplished by extracting with ethanol, acetone, or isopropanol. Protein content was increased to about 75% with a loss of about 5% of the nitrogen. Preliminary food evaluation was made by incorporating this flour in bread and in meat-substitute dishes.

NEW CROPS UTILIZATION
Northern Utilization Research and Development Division, ARS

Problem. Farmers could achieve more economic use of their land if new and profitable crops were available for their choice that would have different end-use patterns from those presently grown. For example, it would be advantageous to develop a new oilseed crop yielding unique fatty acids that could find industrial use in applications for which acids from presently available domestic oilseed crops are unsuitable. To develop a new crop, three basic steps are involved: (1) survey of wild plants, in cooperation with plant scientists, to identify those having both potentially valuable components and promising agronomic potential for use in the United States; (2) detailed physical and chemical studies on components of interest to obtain clues to likely end uses; and (3) selection of the most promising species, followed by additional utilization research to explore uses and demonstrate industrial potential, as well as by additional agronomic research to establish proper cultural practices and to select the best strains and varieties. Only after these steps have been successfully accomplished can a proposed new crop be offered to agriculture and industry for introduction and development. Obviously, a program of this type is a long-range one. Yet, whether the future of agriculture involves conditions of surplus, of greater emphasis on foods and feeds, or of necessity for greater national self-sufficiency, the nation will benefit from availability of optimum, practical crop plants to serve its needs.

Research on new crops has already revealed several promising plant sources of new products that should have valuable industrial uses. These products include water-soluble gums, pulp fibers, and oils containing unique fatty acids such as hydroxy-unsaturated acids, capric acid, epoxidized acids, and unusual long-chain fatty acids.

One new crop, crambe, has a seed oil rich in erucic acid, which is currently obtained from imported rapeseed oil. Crambe has recently achieved commercialization and the outlook for it to become an important crop is encouraging.

To find still other desirable new crops, continued screening and characterization research is needed. Evaluation of the potential of new materials discovered requires further work on their physical and chemical properties and reactions and on processing to obtain maximum recovery from source plants.

USDA AND COOPERATIVE PROGRAMS

The Department conducts a long-range, continuing program of research involving analytical and organic chemists and chemical engineers engaged in examination of uncultivated plants to find unusual and potentially useful

components and in detailed characterization and evaluation studies of selected components that have the greatest industrial potential and that are obtainable from agronomically promising plants. Plants or seeds for this program are obtained by cooperation with Crops Research Division which procures material from domestic and foreign sources by means of collecting trips or from experimental plantings. Materials from abroad are also made available through Crops Research Division PL 480 projects providing for collecting activities by foreign investigators. All seeds and plants are submitted to a broad chemical screening program to identify sources of unusual and potentially useful components such as oils, fibers, and gums. Components of interest from plants rated by Crops Research Division as having a reasonable agronomic potential for the United States are characterized to obtain clues to areas of utilization of probable interest to industry. On the basis of the results, plants having the highest agronomic potential and containing components of greatest potential industrial value are selected for more intensive utilization research.

The Department maintains a continuing but limited program involving one professional analytical chemist who devotes a portion of his time to screening uncultivated plants to find possible sources of new amino acids and proteins and to study of amino acids and proteins of meals obtained from new potential oilseed crops.

The Federal program at Peoria, Illinois, totals .4 scientist man-year, all of which is devoted to chemical composition and physical properties.

The Federal scientific effort for research on new crops as sources of industrial products totals 8.0 scientist man-years. Of this number, 6.2 are devoted to chemical composition, physical properties and structure, and 1.8 to technology - process and product development.

Research on chemical composition, physical properties and structure is conducted at Peoria, Illinois, and includes conduct of the program on screening uncultivated plants for new oils, fibers, gums, and other components of potential value to industry; organic chemical characterization of selected components, especially new oils and fatty acids; and studies on properties of new plant fibers.

Research on technology - process and product development, also conducted at Peoria, Illinois, is concerned with studies on pulping new fiber plants and evaluation of the pulp in paper, structural boards, and related products. During the reporting period, studies on fiber plants other than kenaf were completed and emphasis on kenaf was increased accordingly.

The Department also sponsors research in this area conducted by foreign institutions under grants of PL 480 funds. Research on chemical composition, physical properties and structure involves grants to the Institute of General Chemistry, Warsaw, Poland, for determination of glyceride structure of erucic acid oils (5 years, 1962-1967); and to the Swedish Seed Association, Svalof, Sweden, to find new erucic acid oilseeds (5 years, 1963-1968).

Research on new crops conducted by the Eastern Utilization Research Division at Wyndmoor, Pa., and by the Western Utilization Research Division at Albany, Calif., was terminated at the end of fiscal year 1965. Publications and patents based on research conducted at the Eastern Utilization Research Division prior to July 1, 1965, and not previously reported are included with the publications at the end of this section of the report.

PROGRAM OF STATE EXPERIMENT STATIONS

A combined total of 11.0 scientist man-years is devoted to research on industrial and feed uses of new crops.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Chemical Composition, Physical Properties and Structure - Industrial

1. Screening for new industrial oils. During the year, 898 samples were received, of which 481 were new species (total new species since inception of the program 4,430). Screening analyses were performed on 620 samples and 441 oils were analyzed. Some of the more significant results are as follows.

Two richer sources of the C_{18} allenic acid, 5,6-octadecadienoic (laballenic) acid, have been found in the mint family: Eremostachys speciosa (21.5 percent laballenic acid in the oil) and Phlomis austra-anatolica (20 percent). The allenic acid found in various species of mint should have unique industrial uses. These species are, therefore, being reviewed with Crops Research Division botanists to determine if agronomic potential of any species is adequate to support developmental studies.

Two species of Coriaria (shrubs) yielded oils containing some 60 percent of a new hydroxy conjugated dienoic acid.

Seed oil of a Picris species from Pakistan contained 30 percent crepenynic acid.

A number of new sources of vernolic acid were found. These comprise five new accessions of Euphorbia lagascae from Spain, four new species of Vernonia from Ethiopia, and one species of Schlectendalia from Uruguay. Analyses were performed on 227 samples from four groups of V. anthelmintica grown in Indiana. Three of the groups showed fairly consistent oil (21-29

percent) and vernolic acid (64-74 percent) content, whereas the fourth showed wide compositional variation (16-26 percent oil; 37-76 percent vernolic acid). These studies have enhanced the prospects for eventual successful commercialization of Vernonia because they show that one group of samples from the Indiana trials maintains variability needed for breeding studies. Selections based on our analyses will be made by cooperating agronomists at Purdue University. Discovery of additional sources of vernolic acid broadens the base for agronomic studies.

Under a PL 480 grant to the Swedish Seed Association, Svalof, Sweden, scientists have been studying the composition of Swedish Cruciferae seeds. By comparison of results from plantings in the different environments of Sweden and Turkey, it was shown that genetic factors are more important than climatic ones in controlling erucic acid content of turnip-rape and white mustard. A spectrum of variability in erucic acid content from 36 percent to 55 percent has been found in oil from single seeds of Brassica carinata, an oilseed with good agronomic potential for the United States. No oilseed of the mustard family has yet been found with more than 66-2/3 mole-percent of 22-carbon acids, so this level may be the highest attainable by plant breeding.

2. Screening for new pulp fiber plants. Samples of Sesbania exaltata and Aeschynomene scabra (both members of the bean family) were evaluated as possible sources of cellulosic fibers. The Aeschynomene appeared inferior to kenaf in several respects, but the Sesbania pulp had properties that might make it preferred for selected types of paper.

3. Characterization of seed oils and component fatty acids. In characterization studies, the structures of the following component acids of seed oils from the source indicated were established: 9,10,18-trihydroxystearic acid (Chamaepeuce sp.); 9-hydroxy-trans-10,cis-12-octadecadienoic and 13-hydroxy-cis-9,trans-11-octadecadienoic acids (Xeranthemum annuum); 15-oxo-cis-18-tetracosenoic, 17-oxo-cis-20-hexacosenoic, and 19-oxo-cis-22-octacosenoic acids (Cuspidaria pterocarpa); 13-D-hydroxy-cis-9,trans-11-octadecadienoic acid (coriolic acid; Coriaria nepalensis). The complete structure was established for α-parinaric acid, i.e., cis-9,trans-11,trans-13,cis-15-octadecatetraenoic acid.

Seed oil of Jurinea anatolica contained 41 percent of esters of triterpene alcohols. Esters present are acetates (76 percent), palmitates (16 percent), and myristates (8 percent). Five triterpene alcohols are involved. All were identified. These unusual triterpene esters exemplify a type of product radically different from the glyceride oils commonly described in our reports. Wide-ranging industrial applications for these unusual oils can easily be imagined, but much further work will be needed to determine if practical consequences can reasonably be anticipated from this discovery.

Monoacetotriglycerides in oil of Euonymus verrucosus were shown to be optically active and to consist of S(-)-α-acetotriglycerides. Most of the glycerides of Impatiens edgeworthii are monoacetotriglycerides. The hydrogenated oil was optically active. Discovery of optically active acetotriglyceride oils is a notable scientific "first." Heretofore, no unmodified, naturally occurring glyceride was known in which optical activity was solely due to assymetry of the β-glycerol carbon atom.

The triglyceride structure of oils high in erucic acid content is being studied under a PL 480 grant to the Institute of General Chemistry, Warsaw, Poland. Based on data from gas-liquid chromatography and enzymatic hydrolysis with pancreatic lipase, the mole percentages of the principal triglycerides present in 10 selected cruciferous seed oils have been calculated. The molecular composition of crambe seed oil appears to be simpler than that of the others, since 66 mole-percent of its total oil can be accounted for by only three principal glycerides, in which the primary alcohol groups of glycerine are esterified exclusively with erucic acid and the secondary alcohol group is esterified with oleic, linoleic and linolenic acids, respectively.

B. Technology - Process and Product Development - Industrial

1. Kenaf for pulp and paper. A detailed comparison was made of the pulping characteristics of green kenaf, at several stages of maturity, grown in northern Florida and central Illinois. Yields of unbleached screened pulps were 55 percent for Florida kenafs harvested at 120 or 150 days, whereas the maximum yield for Illinois kenaf was about 50 percent for frost-killed material. Florida kenaf harvested at 180 days and frost-killed Illinois kenaf gave about the same yield of bleached pulp (47 and 45 percent, respectively). Florida material gave the higher yields of bleached pulp in other comparisons. Differences in performance of paper attributable to geographic location were not great.

Further studies on bleaching chemi-mechanical kenaf pulps resulted in an improved and more economical procedure for achieving a brightness of 60 for newsprint formulations. Newsprint-type papers have been achieved that are equivalent to commercial newsprint except for a slight deficiency in opacity.

Industrial interest in annual plants for pulp remains at a high level among paper companies, which have expressed the belief that annual pulp crops will eventually be used on a large scale. Our most recent information indicates that the increasing scarcity and cost of labor is the motive force in this direction, not shortage of wood pulp. Both the high yield and annual harvest favor a crop such as kenaf. For example, an acre of loblolly pine produces, at 15-year intervals, about 2.5 tons of material at 50 percent moisture, including bark. Sustained annual yields of kenaf solids run from 5 to 7 tons (dry basis) per acre. The possibility of mechanized handling of an annual plant grown on convenient and relatively compact acreage is unquestionably attractive to industry. Kenaf may well prove to be an annual crop suitable for the type of operation now foreseen by industry.

C. Chemical Composition and Physical Properties - Feeds

1. Amino acid analyses were run on seed proteins from 32 species representing 7 plant families. This work is part of a comprehensive survey of seeds as protein sources. Results of the survey, which covered 4,000 species, showed that some species contain amino acids in proportions implying good nutritional balance. Although not themselves balanced, proteins of other species were rich in amino acids that could supplement diets based primarily on cereal grains. The data provide a sound basis for agronomic studies, field trials, and animal tests leading to possible new feed and food crops.

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Chemical Composition, Physical Properties and Structure - Industrial

Bagby, M. O., Smith, C. R., Jr., and Wolff, I. A. 1965. Laballenic acid. A new allenic acid from Leonotis nepetaefolia seed oil. J. Org. Chem. 30(12), pp. 4227-4229.

Clark, T. F. 1965. Plant fibers in the paper industry. Econ. Botany 19(4), pp. 394-405.

Craig, J. C.,[1] Roy, S. K.,[1] Powell, R. G., and Smith, C. R., Jr. ([1]University of California, San Francisco, California). 1965. Optical rotatory dispersion and absolute configuration. VI. Structure and absolute configuration of helenynolic acid. J. Org. Chem. 30(12), pp. 4342-4343.

Goering, K. J., Eslick, R., and Brelsford, D. L. (Montana State College, Bozeman, Montana). 1965. A search for high erucic acid-containing oils in the Cruciferae. Econ. Botany 19(3), pp. 251-256.

Goering, K. J., and Yao, J. (Montana State College, Bozeman, Montana). 1964. Use of dye binding method for protein estimation in Cruciferae meals. Proc. Montana Acad. Sci. 24, pp. 59-60.

Jones, Q.,[1] and Earle, F. R. ([1]USDA Crops Res. Div., Beltsville, Maryland). Chemical analyses of seeds. II. Oil and protein content of 759 species. Econ. Botany 20(2), pp. 127-155.

McGrew, C., and VanEtten, C. H. 1966. Microdetermination of sulfur and halogens in nonvolatile substances in solution by the Schöniger flask method. Trans. Illinois State Acad. Sci. 59(1), pp. 58-61.

Mikolajczak, K. L. Nov. 9, 1965. Process for producing undecanedioic acid from plant sources. U. S. Patent 3,216,046.

Mikolajczak, K. L., Bagby, M. O., Bates, R. B., and Wolff, I. A. 1965. Prototropic rearrangement of a 1,4-enyne. Products and mechanism. J. Org. Chem. 30(9), pp. 2983-2988.

Mikolajczak, K. L., Smith, C. R., Jr., and Wolff, I. A. 1965. Dihydroxy fatty acids in Cardamine impatiens seed oil. J. Am. Oil Chemists' Soc. 42(11), pp. 939-941.

Miller, R. W., Earle, F. R., Wolff, I. A., and Jones, Q.[1] ([1]USDA Crops Res. Div., Beltsville, Maryland). 1965. Search for new industrial oils. XIII. Oils from 102 species of Cruciferae. J. Am. Oil Chemists' Soc. 42(10), pp. 817-821.

Nelson, G. H., Clark, T. F., Wolff, I. A., and Jones, Q.[1] ([1]USDA Crops Res. Div., Beltsville, Maryland). 1966. A search for new fiber crops: Analytical evaluations. Tappi 49(1), pp. 40-48.

Powell, R. G., and Smith, C. R., Jr. 1966. New acetylenic fatty acids from Acanthosyris spinescens seed oil. Biochemistry 5(2), pp. 625-631.

Powell, R. G., Smith, C. R., Jr., Glass, C. A., and Wolff, I. A. 1966. New enynolic acids from Acanthosyris. Structures and chemistry. J. Org. Chem. 31(2), pp. 528-533.

Smith, C. R., Jr., and Miller, R. W. 1965. A C_{26}-keto-acid from the oil of Cuspidaria. Chem. Ind. (London) (46), p. 1910.

Smith, C. R., Jr., and Wolff, I. A. 1966. Glycolipids of Briza spicata seed. Lipids 1(2), pp. 123-127.

Chemical and Physical Investigations to Improve Products - **Industrial**

Miwa, T. K., and Wolff, I. A. Dec. 28, 1965. Method of preparing a wax ester substitute for jojoba oil. U. S. Patent 3,226,406.

Tookey, H. L., and Clark, T. F. 1965. Evaluation of seed galactomannans from Cassia species as paper additives. Tappi 48(11), pp. 625-626.

Technology - Process and Product Development - **Industrial**

Miller, D. L. 1965. Kenaf--A potential papermaking raw material. Tappi 48(8), pp. 455-459.

RELATED PUBLICATIONS OF STATE EXPERIMENT STATIONS

(Publications on industrial and feed utilization of new crops including castor, safflower, and other oilseeds.)

Chemical Composition, Physical Properties and Structure

Anon. 1965. Forage crop varieties for Montana. Mont. Agr. Exp. Sta. Circ. 242, 69 pp. (Mont.)

Anon. 1965. Baco, a new combine sesame. Texas Agr. Exp. Sta. Leafl. 644, pp. 1-2. (Tex.)

Brewbaker, J. L., and Hylin, J. W. 1965. Variations in mimosine content among Leucaena species and related Mimosaceae. Crop Sci. 9(4), pp. 348-349. (Hawaii)

Corley, W. L. 1965. Some preliminary evaluations of okra plant introductions. Ga. Agr. Exp. Sta. Bull. N. S. 145. (Ga.)

Creel, G. C., Ericson, J. E., and Schulz-Schaeffer, J. 1965. Biosystematic investigations in the genus Agropyron Baertn. III. Serological, morphological, and cytological comparison of species within the crested wheatgrass complex (section Agropyron). Crop Sci. 5, pp. 316-320. (Mont.)

Dam, R., Lee, S., Fry, P. C., and Fox, H. 1965. Utilization of algae as a protein source for humans. J. Nutrition 86, pp. 376-382. (Nebr.)

Killinger, G. B. 1965. Kenaf, Hibiscus cannabinus L. and Erucastrum abyssinica as potential industrial crops for the South. Proc. Assn. Southern Agr. Workers Inc., pp. 54-55. (Fla.)

Knowles, P. F. 1965. Variability in oleic and linoleic acid contents of safflower oil. Econ. Botany 19, pp. 53-62. (Calif.)

Knowles, P. F., et al. 1965. Safflower. Calif. Agr. Exp. Sta. Circ. 532, pp. 1-51. (Calif.)

Mann, H. O., and Haus, T. E. 1965. Safflower testing. Colo. Agr. Exp. Sta. Progress Report 174, pp. 1-2. (Colo.)

Martin, J. A. 1965. Gourds of all types for garden and market. S. C. Agr. Exp. Sta. Res. Ser. 64. (S.C.)

Rogers, Marlin N. 1965. Chemical growth retardants for poinsettias. Mo. State Flor. News 26(4), pp. 3-8. (Mo.)

PUBLICATIONS AND PATENTS -- USDA AND COOPERATIVE PROGRAMS [1/]

Chemical Composition, Physical Properties and Structure

Lutz, D. A. and Scott, W. E. 1966. Crystal data for (-)-threo-12,13-dihydroxyoleic acid. Acta Crystallographica 20, 309.

Chemical and Physical Investigations to Improve Products

Scott, W. E. and Riser, G. R. 1966. Effect of storage temperatures on the stability of trivernolin. J. Am. Oil Chem. Soc. 43, 55-56.

Technology - Process and Product Development

Krewson, C. F. and Scott, W. E. 1966. *Euphorbia lagascae* Spreng., an abundant source of epoxyoleic acid; seed extraction and oil composition. J. Am. Oil Chem. Soc. 43, 171-174.

Krewson, C. F., Scott, W. E. and Riser, G. R. 1966. *Euphorbia* and *Vernonia* seed oil products as plasticizer-stabilizers for poly(vinyl chloride). J. Am. Oil Chem. Soc. 43, 377-379.

Riser, G. R., Riemenschneider, R. W. and Witnauer, L. P. Vernolic acid esters as plasticizers for poly(vinyl chloride). Galley proof returned to J. Am. Oil Chem. Soc. 5/18/66.

Krewson, C. F., and Scott, W. E. January 18, 1966. Process for obtaining *Vernonia anthelmintica* seed oil. U. S. Patent 3,230,239.

1/ Publications not previously reported, based on research conducted at the Eastern Utilization Research and Development Division prior to termination of the program there July 1, 1965.

NUTRITION AND CONSUMER USE RESEARCH

Consumer and Food Economics Research Division, ARS
Human Nutrition Research Division, ARS

Problem. The assortment and characteristics of food available to consumers change constantly with the adoption of new practices of production, processing, and marketing. Changing constantly also, as nutrition science advances, is our understanding of the nutritional needs of man and the manner in which these needs can best be met by food. To help meet the Department's responsibility to advise consumers on the quantity and variety of foods that will assure maximum benefit and satisfaction, research must continue on the nutritional requirements of persons of all age groups, on the nutrient and other values of foods, and on ways to conserve or enhance these values in household and institutional preparation and processing.

The kinds and amounts of foods consumed by different population groups and individuals must be determined periodically by surveys so that the nutritional adequacy of diets can be evaluated. Information on food consumption and dietary levels provides the guidelines needed for effective nutrition programs. This information also furnishes the basis for market analyses for different commodities and for development and evaluation of agricultural policies that relate to production, distribution, and consumer use of food.

USDA AND COOPERATIVE PROGRAM

The Department has a continuing program of research concerned with (1) nutritive and other consumer values of raw and processed foods as measured by chemical or physical means and by biologic response; (2) effects of household practices upon the nutritive values and inherent qualities of foods, and the development of improved procedures for household food preparation, care and preservation; (3) nutritional appraisal of food supplies and diets of different population groups; and (4) development of guidance materials for nutrition programs.

The research is carried out by two divisions of the Agricultural Research Service -- the Human Nutrition and the Consumer and Food Economics Research Divisions. Most of the work is done at Beltsville and Hyattsville, Maryland; some is done under cooperative, contract, or grant arrangements with State Experiment Stations, universities, medical schools, research institutes, and industry. The total Federal scientific effort devoted to research in these areas is 72.6 man-years. It is estimated that 2.4 scientific man-years is concerned with studies related to oilseeds and peanuts.

Human metabolic studies and the related exploratory and confirmatory studies with experimental animals and microorganisms concerned with defining human

requirements for nutrients and foods are not reported on a commodity basis, though some of the work is applicable to this report. This basic nutrition research represents a total Federal effort of 21.1 scientific man-years and is described in detail in the report of the Human Nutrition Research Division. Certain aspects of this research related to fats and oils are considered briefly in this report.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Quality and Use of Oilseed and Peanut Flours

Research has continued at Beltsville on quality and food uses for cottonseed, peanut, and soy flours in cooperation with the Agency for International Development. Flours processed by the Northern and Southern Utilization Research and Development Divisions have been evaluated for their quality and potential use by families and community groups in various countries of the world where these plant proteins can be produced. The formulas developed for using the plant-protein flours have been standardized in serving portions. A reference handbook containing formulas and recommendations will be prepared.

Cooperative research was initiated at Howard University in Washington, D.C., on food products suitable for some African and Asian countries. The food products use soy and peanut flours in combination with foods ordinarily available in the developing countries. Students from a number of Asian and African countries will participate and some of the products also will be evaluated by the response of nursery school children. This work will continue at an accelerated rate in an effort to find a number of suitable new items from cottonseed, peanut, and soy flour for feeding to persons in various age groups in various countries.

B. Nutrient Values of Peanuts and Soybeans

1. Peanuts. Studies on the effect of the use in the soil of a chlorinated pesticide, lindane, on the nutrients of raw and roasted peanuts were initiated under contract at the Texas Agricultural Experiment Station at College Station. Lindane is not used in the production of peanuts but may be present in the soil from previous crops. Lindane is known to affect the metabolism of peanuts because off flavors develop when it is present in the soil during growth. For this reason peanuts were selected for study of the possible effect of lindane upon nutrient content of plant foods. The nutrients include the individual amino acids and fatty acids, and the B-vitamins--thiamine, riboflavin, and niacin.

2. Soybeans. Researchers in Osaka, Japan, studying the nutrients in tempeh, a product of the mold fermentation of cooked soybeans, have found an increase in values for B-vitamins over those in unfermented soybeans. This research is being done under a PL 480 contract. The data showed a net increase in riboflavin, vitamin B_6, and nicotinic acid but not of thiamine. The investigators

found increased protein utilization by rats of tempeh over raw soybeans, and an antihemolytic response to tempeh by animals under vitamin E deficient conditions. Some of these findings were reported at the 19th annual meeting of the Japanese Society of Food and Nutrition, May 1965; others will be presented at the VIIth International Congress of Nutrition in Hamburg, Germany, August 1966.

C. Nutritional Evaluation of Fats and Oils

1. Heated and oxidized fats. Research on fats and oils mildly oxidized by aeration at 140° F. for 40 hours has continued under a research contract with Columbia University at New York City, and has been extended to include information on the response of rats to soybean oil. Mild oxidation has consistently resulted in longer survival for rats fed mildly oxidized olive oil, corn oil, and soybean oil than for those fed the fresh oils. In contrast, survival was similar for rats fed fresh and oxidized fats (lard, beef, chicken, and butter) and did not differ from the results obtained with the three oxidized oils. The results obtained suggest that further research is warranted to determine the cause for the reduced survival observed with the fresh oils.

A report of some of the findings from this research, "Nutritional effects of some fresh and mildly oxidized animal and vegetable fats" was presented to the American Oil Chemists Society in April 1966. A paper entitled "Longer survival of rats fed oxidized vegetable oils" will be presented at the VIIth International Congress of Nutrition in Hamburg, Germany, August 1966.

2. Dietary fat and cholesterol synthesis. The body continuously synthesizes cholesterol, which is essential for normal function but which may be associated with certain pathological conditions. The rate of cholesterol synthesis may be significantly influenced by diet. In recent studies at Beltsville, the influence of type of fat on cholesterol synthesis was investigated. When rats were fed a diet containing 20 percent corn oil, cholesterol synthesis was considerably greater than when the diet contained 20 percent beef tallow. In spite of marked differences in rate of synthesis, no differences were observed in the levels of cholesterol in the serum. A manuscript presenting these data has been submitted for publication.

3. Dietary linoleic acid levels and nitrogen and mineral balance. Data obtained in contract research at the University of Alabama on the metabolic response of 7 young men to a controlled diet with variations in dietary linoleic acid have been published. The results showed that increasing the linoleic acid content of dietary fat from 10 percent to 26 percent resulted in small changes of doubtful biological importance in serum levels of cholesterol and phospholipids. There was no significant change in the retention of nitrogen and minerals. The minerals studied were sulfur, calcium, phosphorus, magnesium, sodium, and potassium.

4. Nutrient interactions. A PL 480 study has provided further evidence that the effects of various dietary components may differ markedly with the food pattern consumed. Diets patterned after the protein-fat combinations typical

of those in three regions of India--North, Central, and South--were fed to rats to investigate the influence of diet on fat metabolism. Omission of the vitamin and mineral mixtures commonly used to assure adequacy of these nutrients in the diet of the rat resulted in lowering the high cholesterol observed with the diet combination of high animal protein and saturated fat that is consumed in North India. Omission of these fortifying mixtures caused an increase in serum cholesterol when rats were fed the chick pea-sesame oil diet of Central India. Omission from the bean-coconut oil combination of South India resulted in extremely high levels of blood cholesterol and neutral fat. Thus, not only the kind and amount of dietary fat was important and the kind and amount of protein and carbohydrate but also the relative amounts of the minerals and vitamins. These studies are to be extended to confirm these findings and to seek an explanation for the results obtained.

D. Tables of Food Composition

1. Vitamin E. A review of the vitamin E content of more than 5,000 food and feed items used for human and/or animal consumption was completed and published by the University of Wyoming at Laramie. This review was proposed and partially supported by the Human Nutrition Research Division. A total of 455 references were reviewed and fewer than 40 contained information on individual forms of tocopherols. The review was instigated by the increased recognition given to the importance of the tocopherols in metabolism of polyunsaturated fats and the extent of their use as naturally occurring antioxidants.

2. B-vitamins and trace elements in foods. Summarization of data and derivation of representative values are nearing completion for a publication on the content of pantothenic acid, vitamin B_6 and vitamin B_{12} in foods. The values will be given in terms of milligrams of the nutrient per 100 grams of edible portion and per 1 pound as purchased for each food item.

Also nearing completion is a preliminary table summarizing the data for 22 trace elements in foods arranged in 15 food groups. Data representing over 6,500 food samples analyzed for 1 to 22 trace elements have been reviewed, recorded on cards for punching, and sorted by specific food. This table is particularly useful for indicating foods and food groups for which data are very limited or are conflicting.

3. Special services. Information on the nutritive value of foods was supplied for inclusion in textbooks on nutrition, diet therapy, and medicine, and several almanacs; also for use in investigations of misleading labeling of foods and false advertising claims, and, as background for developing research projects. Information and technical assistance were given also to research teams conducting dietary surveys, to professional workers engaged in educational, welfare and health programs, and to representatives of the Food for Peace Program and the Food and Agriculture Organization of the United Nations.

E. Food Conumption and Diet Appraisal

1. 1965 nationwide survey. Collection of data from the more than 15,000 households and 13,000 individual family members cooperating in the nationwide survey of food consumption in the United States is now complete. Tabulation of the data for households and preparation for tabulation of the data on individuals are in progress.

Preliminary review of the household data shows that family expenditures for food averaged $33 a week in the spring of 1965. Of this, $27 went for food bought and used at home, $6 for meals and snacks eaten away from home. Home-produced and other foods for which no direct money outlay was made were valued at $2. The money value of the food used averaged $10.65 per person.

The total money value of food per family was 17 percent greater in the spring of 1965 than in 1955 when a similar survey was made. Most of the increase can be attributed to higher food prices but there was also a substantial increase in spending by farm families for food bought and eaten away from home. Their expenditures for eating out nearly doubled in the 10-year period and took 11 percent of total food money in 1965 compared to 7 percent in 1955. A report of these preliminary findings of the money value of food of households is being prepared.

Later, information will be available on the types and quantities of foods used by families in the spring of 1965. There will be information on approximately 250 foods--the percentages of families using the foods, average amounts and the money value of the food used. Where pertinent, data will be shown separately for purchased, home-produced, and Federally donated food. Publications will be prepared on dietary levels provided by the foods used. Similar information will be published also for the 4 seasons. For individual family members, data will be reported for about 20 different sex-age groups, for the U.S. total and probably for 2 regions.

2. Diets and nutriture of preschool children. A study was initiated to determine the nutritional situation of children, 2 and 3 years of age, in low-income families in Hawaii. Children from the low-income families will be compared with those from higher income families with similar ethnic backgrounds. Biochemical, clinical, and psychomotor tests will be used to assess nutritional state. Correlations will be sought with social and economic characteristics of the child's family. The study will be done under a Cooperative Agreement by the University of Hawaii.

3. Nutritive value of national food supply. Estimates of food energy (calories) and selected nutrients provided by the per capita food supply are calculated each year from data on apparent civilian consumption, retail basis, developed by the Economic Research Service. The estimates indicate that for the past 10 years, the level of food energy has remained around 3,150 calories per capita per day--about 10 percent lower than in 1909-1913. This lower calorie level is the net result of about a 25 percent decrease in carbohydrate available for consumption, a 15 percent increase in available fat and a slight

decrease in available protein, between 1909-1913 and 1965. This shift in the composition of the food supply caused the percentage of total calories furnished by carbohydrate to drop from 56 to 47 and the percentage of total calories furnished by fat to rise from 32 to 41. The percentage of total calories furnished by protein remained at about 12.

4. Nutritive content of school lunches. A nationwide study of the nutritive content of type A school lunches as served to sixth graders was initiated in cooperation with the School Lunch Division, Consumer and Marketing Service. Plans call for the collection and analysis of 20 lunch composites from 300 schools located in 19 states in five geographic regions. The objective is to provide data needed in evaluating the type A pattern. Because the pattern specifies the minimum amounts of foods required but does not specify maximum amounts that are allowed, the fat content of the lunches is of special concern.

5. Support for food and nutrition programs. Developments in nutrition research continue to be studied and interpreted for application to problems in food selection and food use.

In anticipation of the expansion of child feeding programs, meal patterns for breakfasts and dinners suitable for children of all ages, were developed at the request of the School Lunch Division, Consumer and Marketing Service. These meal patterns will serve as guidelines for planning meals to meet the needs of children for food energy and the major nutrients. The patterns may be used independently or in conjunction with the type A lunch pattern.

To help promote better nutrition among low-income families, NCU food specialists and nutrition specialists cooperated with other Department agencies in the preparation of a teaching kit "Food for Thrifty Families." The kit consists of an adaptation of the "Daily Food Guide" and a series of 20 fliers that contain information on nutrition and simplified recipes for donated foods relatively low in cost. The kit includes a flier on peanut butter.

The bimonthly publication of Nutrition Program News was continued. This publication reaches about 7,000 workers in nutrition and related fields. Talks to groups involved in community nutrition programs, radio tapes, and consultant help and participation in conferences contributed to coordinating and strengthening of nutrition programs.

Preliminary plans were made for the fifth National Nutrition Education Conference which will be held in February 1967. The conference is cosponsored by CFE and the Interagency Committee on Nutrition Education. The theme will be coordination and communication in nutrition programs.

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Lipids

Dupont, J. 1965. Relationship between utilization of fat and synthesis of cholesterol and total lipid in young female rats. Jour. Am. Oil Chem. Soc. 42, 903-907.

Kaunitz, H., Johnson, R. E., and Pegus, L. 1965. A long-term nutritional study with fresh and mildly oxidized vegetable and animal fats. Jour. Am. Oil Chem. Soc. 49, 770-773.

Kaunitz, H. 1966. Some etiological factors in obesity. Jour. Am. Oil Chem. Soc. 43, 175-179.

Lakshmanan, F. L., and Adams, M. 1965. Effect of age and dietary fat on serum protein components of the rat. Jour. Nutr. 86, 337-342.

Wiese, H. F., Bennett, M. J., Coon, E., and Yamanaka, W. 1965. Lipid metabolism of puppies as affected by kind and amount of fat and dietary carbohydrate. Jour. Nutr. 86, 271-280.

Nutritional Value

Campbell, A. M., Swendseid, M. E., Griffith, W. H., and Tuttle, S. G. 1965. Serum lipids of men fed diets differing in protein quality and linoleic acid content. Amer. Jour. Clinical Nutr. 17, 83-87.

Edwards, C. H., Rumph, C. H., Booker, L. K., and Ganapathy, S. N. 1966. Effects of diets containing wheat and wheat supplemented with pinto beans, rice, or peanut butter on plasma lipids of young men. Fed. Proc. 25, No. 2, 607. (Abstract.)

Oldham, H. G., and Dickinson, F. N. 1965. Evaluation of nitrogen balance of young women fed amino acids proportioned as in the FAO provisional pattern and as in egg, oats, milk, and peanuts. Amer. Jour. Clinical Nutr. 17, 360-366.

Nutrient Values

Bluestone, B., and Vandersall, P. K. 1965. Saving food values. Chapter in Consumers All, 1965 Yearbook of Agriculture. pp. 432-435.

Dicks, M. W. 1965. Vitamin E content of foods and feeds for human and animal consumption. Bulletin 435, Wyoming Agricultural Experiment Station, University of Wyoming, 194 pp.

Nutritive Value of National Food Supply

Friend, B. 1965. Nutritional review. Natl. Food Sit. NFS-114. Outlook issue. November.

Friend, B. 1966. Nutritive value of food available for consumption, United States, 1909-64. ARS 62-14. January.

Consumer Use

1965. Family meals at low cost--Using donated foods. Consumer and Marketing Service, Human Nutrition Research Division. Program Aid 472, 16 pp. (Rev.)

1965. Quantity recipes for type A school lunches. Consumer and Marketing Service; Agricultural Research Service; Fish and Wildlife Service, Department of the Interior. Program Aid 631. (Card File). (Rev. of PA-271).

1966. A menu planning guide for type A school lunches. Consumer and Marketing Service, Agricultural Research Service. Program Aid 719, 16 pp.

1966. Money-saving main dishes. Human Nutrition Research Division, Consumer and Food Economics Research Division. Home and Garden Bulletin No. 43, 45 pp.

Hill, M. M. 1965. Food to satisfy. Chapter in Consumers All, 1965 Yearbook of Agriculture, pp. 393-397.

Page, L. 1965. Calories and weight. Chapter in Consumers All, 1965 Yearbook of Agriculture, pp. 398-402.

Food Plans and Food Budgets

Consumer and Food Economics Research Division. 1965. Cost of food at home. Family Economics Review. October, pp. 20-21; December, p. 28. 1966. March, pp. 20-22; June, p. 14.

Peterkin, B. 1965. When you buy food. Chapter in Consumers All, 1965 Yearbook of Agriculture, pp. 416-419.

Peterkin, B. 1966. The cost of USDA food plans and family grocery bills. Family Economics Review. June, pp. 13-17.

Peterkin, B., and Clark, F. 1966. How families spend their food dollars. Family Economics Review. March, pp. 3-6.

PUBLICATIONS -- STATE EXPERIMENT STATIONS 1/

Nutritional Value

Borgman, R. F. 1965. The effects of a vitamin E-low diet containing oleic acids in rats. Dept. Food Science & Biochemistry, Clemson Univ., Clemson, South Carolina, Res. Ser. 11.

Borgman, R. F. 1965. Gallstone formation in rabbits as affected by dietary fat and protein. South Carolina. Am. Jour. Vet. Res. 26, 1167-1171.

Bring, S. V. 1965. Effect of dietary fat upon cholesterol and vitamin A metabolism in the rat. Idaho Research Bul. No. 66, Idaho Agricultural Experiment Station, Moscow, Idaho.

Carroll, G., and Bright, E. 1965. Influence of carbohydrate-to-fat ratio on metabolic changes induced in rats by feeding different carbohydrate-fat combinations. Arkansas. Jour. Nutr. 87, 202-210.

Heywang, B. W., and Vavich, M. G. 1965. Comparison of performance of layers fed soybean, glandless or glanded cottonseed meals. Arizona. Poultry Sci. 44, 1240-1244.

Morse, E. H., Lewis, E. P., Merrow, S. B., Widlund, E. M., and Newhall, C. A. 1965. Effect of two dietary fats to blood lipids in young men. Vermont. Jour. Amer. Dietet. Assoc. 46, 193-196.

Nutrient Values and Consumer Use Qualities

Heywang, B. W., and Vavich, M. G. 1965. Discolorations in eggs (from chicken) fed cottonseed meals made from glandless and glanded seed. Arizona. Poultry Sci. 44, 84-89.

Kemmerer, A. R., and Heywang, B. W. 1965. Effect of the addition of cottonseed lipids to cottonseed meal on egg discoloration. Arizona. Poultry Sci. 44, 889-910.

Kilgore, Lois. 1965. Composition of unsaturated fats in lard and cottonseed oil. Mississippi. Mississippi Farm Research 28, No. 3.

Perkins, E. G., and Van Akkeren, L. A. 1965. Heated fats. IV. Chemical changes in fats subjected to deep fat frying processes: Cottonseed oil. Illinois. Jour. Amer. Oil Chem. Soc. 42, 782-786.

1/ This is a partial list for the calendar year 1965.

Food Consumption and Diet Appraisal

Barney, H. S., and Morse, R. L. D. 1965. Shopping of low-income homemakers and students compared. Kansas. Dept. of Family Econ., Kansas State Univ., Manhattan.

Bishop, C., Davis, B., and Harper, L. J. 1965. Factors influencing homemakers' food-buying practices and their willingness to try new recipes. Virginia. Va. Agr. Expt. Sta. Bul. 565, 30 pp.

Burk, M. C. 1965. Les changements qualitatifs dans L'Alimentation et leurs repercussions sur L'Agriculture: L'Experience des etats-unis. Minnesota. Economie Rurale No. 66, pp. 31-38.

Dickins, D. 1965. Factors related to food preferences. Mississippi. Jour. Home Econ. 57(6): 427-430.

Lamkin, G., Price, B. L., and Hielscher, M. L. 1965. Food purchasing practices of married students living in university housing. Illinois. Ill. Res. 7, No. 4.

Montgomery, M. 1965. The psychology of food selection: Report of a pilot study. California (Berkeley). Calif. Agr. Expt. Sta. Report. Processed. 116 pp.

Stubbs, A. C. 1965. Homemakers' orientation related to marketing. Texas. Tex. Agr. Expt. Sta. Bul. No. 1041, 12 pp.

Stubbs, A. C. 1965. Food use and potential nutritional level of 1,225 Texas families. Texas. Tex. Agr. Expt. Sta. B-1033, 38 pp.

III. MARKETING AND ECONOMIC RESEARCH

OILSEEDS AND PEANUTS - MARKET QUALITY
Market Quality Research Division, ARS

Problem. Harvested oilseeds and peanuts are subject to deterioration in quality and loss in value through fungus attack and contamination, development of mycotoxins, normal metabolic changes, and instability of their oil constituents to atmospheric oxygen. To maintain the quality, more precise information is needed on the biology, ecology, and control of fungi that attack oilseeds and peanuts; and on the physical and chemical changes and the environmental factors which influence these changes during handling, storage, transportation, and processing. Recent problems with aflatoxin suggest the desirability of a complete re-evaluation of handling and storage methods for farmers stock peanuts. Attention should be given to developing new procedures that would avoid the problems associated with fungi and pesticide residues. Also, to insure uniform and standardized products in the marketing channels, new and improved methods and techniques for measuring quality factors need to be developed for use in inspection, grading, and standardization operations.

Peanut flavor is subject to deterioration through improper aeration, drying, handling, and storing. Earlier studies conducted on the effect of artificial drying on peanut flavor and quality were not conclusive. In addition, studies on shelling of farmers stock peanuts have been initiated and there is need to determine the effect of variables in the drying and shelling operations.

USDA AND COOPERATIVE PROGRAM

The Department has a continuing program involving engineers and chemists engaged in basic and applied research on the quality evaluation, quality maintenance, and development of objective methods of quality evaluation of peanuts, soybeans, and other oilseeds. Research on soybeans is conducted at Washington, D. C., research on peanuts is done at Albany, Georgia, College Station, Texas, and Raleigh, North Carolina, in cooperation with the Texas Agricultural Experiment Station and North Carolina State University.

A P.L. 480 grant with the Vallabhbhai Patel Chest Institute, University of Delhi, India, provides for a study of physiological and biochemical factors involved in the production of aflatoxin by Aspergillus flavus. The project runs from 1965 to 1968 and involves $81,921.52 equivalent in Indian rupees.

A P.L. 480 grant with the Hebrew University in Israel provides for a study of the biology of the fungus Aspergillus flavus Link and its infectivity to plants and harmfulness to animals. The project (Line Project A10-CR-46) runs from 1963 to 1968 and involves $129,250 equivalent in Israeli pounds.

The Federal effort devoted to research in this program totals 4.7 scientific man-years.

The Department also has a continuing program at Tifton and Savannah, Georgia, involving entomologists and chemists engaged in basic and applied research on problems of insect infestation, damage, and contamination, and of pesticide residues in peanuts in the marketing channels. The research is conducted in cooperation with the Georgia Agricultural Experiment Stations, the Agricultural Stabilization and Conservation Services, the Transportation and Facilities Research Division, the Field Crops and Animal Products Research Branch, growers' cooperative associations, and various industry groups.

The Federal effort devoted to research on prevention of insect infestation was 2 scientist man-years during the reporting period. Much of the cross commodity research at Savannah, Georgia, is also applicable to the insect problems in stored peanuts.

PROGRAM OF STATE EXPERIMENT STATIONS

A total of 4 scientist man-years is devoted to this area of research.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Objective measurement and evaluation of quality

1. Equipment for Grading Farmers Stock Peanuts. A device to automatically control the rate-of-feed of the pneumatic sampler probe into loads of farmers stock peanuts has been designed and tested. The tests were conducted on Virginia-type peanuts loaded out of a storage warehouse. Results of the tests indicate that within reasonable limits the rate of feed into loads of farmers stock peanuts does not have a significant effect on the amount of shelled kernels caused by sampling.

Extensive field tests on a cleanout device which prevents peanuts from wedging between the inner and outer tube of the pneumatic sampling probe have been completed. The device performed satisfactorily and was installed on all pneumatic samplers for the 1966 marketing season.

A machine has been designed to comminute large samples of peanut kernels, screen the material through a 1/8" perforated screen and draw a representative subsample for aflatoxin analyses in one operation. The machine will handle about three pounds of kernels per minute without limit to size of sample. The subsamples are 1/10 or 1/20 the original sample size. The machine is small and easily cleaned between samples. Further tests are necessary to determine the accuracy of the subsampler. The machine will make it possible to subsample large samples of peanuts at shelling plants so that only small subsamples will need to be sent to laboratories for aflatoxin analysis. (MQ 3-29)

2. Maturity and Damage Factors in Peanuts. Alcohol dehydrogenase, one of the enzymes thought to be responsible for high-temperature off-flavor, has been isolated from peanut kernels and highly purified. Its kinetic properties were similar to yeast alcohol dehydrogenase. Free boundary electrophoresis and cellulose acetate electrophoresis measurements confirm its high state of purity.

A study of carotenoid pigments in peanut oil has shown that beta carotene and lutein are the major carotenoid pigments responsible for the color of oil from immature peanuts and that oil from mature peanuts has no carotenoid pigments present in amounts down to the nanogram per liter range. Almost complete disappearance of the carotenoid pigments during the maturation process of peanut kernels is thus indicated.

Measurements of the light transmittance of oil expressed from peanuts have been made at 425 mu, 455 mu, and 480 mu wavelengths. The study has shown a correlation between light transmittance of the oil, maturity and some curing treatments. "Ripening" caused by removing vines several days prior to harvesting peanuts from the soil also had an effect on light transmittance. Maturity, curing treatment and pre-harvest removal of vines had significant effects on peanut flavor. The results confirm other studies which indicate that oil color determinations may be useful as objective measurements of peanut quality. Another method for estimating maturity in peanuts was tested. This method is based on the measurement of moisture distribution in peanut kernels. Results showed that the surface moisture of the peanut kernel increases in relation to the total moisture as the peanuts become more mature. (MQ 3-88)

3. Distinguishing Soybean Particles from Foreign Matter. Further studies were made to develop a rapid method for separating soybean particles from foreign material that passes through an 8/64" grading screen. A multistage zig-zag air column separator developed by the Stanford Research Institute removed all of the light foreign material and heavy weed seeds leaving a

concentrated fraction of soybean particles containing a large amount of weed seeds. Use of knurled steel rollers to imbed the soybean particles and lift them out of the weed seeds did not prove to be successful. The possibility of measuring the oil content of the mixture of soybean particles and weed seeds as an index of soybean content of the concentrated fraction is not feasible as it is slower than handpicking the samples. Further work has been suspended pending the outcome of a standardization study by the Grain Division, C&MS, using 5/64 and 8/64 sieves. (MQ 3-24)

4. Rapid Detection of Molds and/or Fungal Metabolites in Peanuts. A new method for the rapid detection of aflatoxin in peanuts was developed. This method is based on milli-column chromatography. A sample of peanuts can be tested in 12 to 15 minutes but a number of samples can be run at the same time. The method is inexpensive and simple in operation. Some degree of quantification is possible by making up standard tubes for comparing with samples. Sensitivity is about 5 to 10 ppb.

The relationship between fat acidity and aflatoxin has been studied in large-seeded Virginia-type peanuts. Fat acidity increased quadratically with increased growth of Aspergillus flavus and was highly correlated ($R = 0.92$) with visible fungal growth. Under the test conditions, fat acidity increased from normal levels of 22 mg KOH to 60 mg KOH per 100 g kernels before aflatoxin became detectable. This relationship suggests the use of a rapid method for determining fat acidity to screen samples of peanuts for the possible presence of aflatoxin.

A rapid method for determining fat acidity in grains was tested on peanuts and found to be in good agreement with the AOAC method. Fat acidity of a sample of peanuts can be determined in about 10 minutes by the rapid method. (MQ 3-66(Rev.))

B. Quality maintenance in handling, drying and storage

1. Storage and Aflatoxin Development in Peanuts. Studies of aflatoxin production in peanuts during commercial storage show that many loads of peanuts going into Segregation I storage contain high levels of aflatoxin. Damaged kernels, loose-shelled kernels and other kernels contained high levels of aflatoxin while sound mature kernels had low amounts. Preliminary results indicate that very little increase in aflatoxin level occurred during storage. (MQ 2-103)

2. Development and Control of Mycotoxins in Virginia-Type Peanuts. Production of aflatoxin in peanuts inoculated immediately after digging with a toxin-producing strain of Aspergillus flavus was studied during windrow harvesting and bulk curing treatments in cooperative studies with

North Carolina State College. Results indicate that, under North Carolina weather conditions, recommended windrow harvesting treatments and bulk curing methods prevent contamination of peanuts in the hull. In some curing treatments peanuts that were shelled during the harvesting operation (loose shelled kernels) became contaminated with aflatoxin.

Two-phase drying was tested as a means of preventing aflatoxin production in peanuts having an initial growth of Aspergillus flavus at the start of the bulk curing process. In the initial phase, elevated drying temperatures up to 150° F. were used to rapidly dry the hulls to arrest further mold growth. The final phase consisted of drying the kernels slowly at less than 95° F. in order to preserve the flavor and milling quality of the peanuts. The results indicate that the hulls can be rapidly dried to less than 20 percent moisture without affecting the flavor or milling quality of the peanuts. However, the two-phase drying treatments used were not effective in preventing contamination of the peanuts with aflatoxin. Much higher levels of aflatoxin were found in loose-shelled kernels than in other peanuts.

The effect of atmospheric composition on the growth of Aspergillus flavus in high moisture peanut kernels has been studied. Treatments included the following atmospheres: 100 percent oxygen; 100 percent nitrogen; 100 percent carbon dioxide; 1 percent to 10 percent oxygen in nitrogen and 65, 75, and 85 percent carbon dioxide in air. The 100 percent nitrogen and 100 percent carbon dioxide treatments prevented spore germination and growth of A. flavus. Low levels of oxygen in nitrogen retarded mold growth to some degree but high levels of carbon dioxide in air were most effective in limiting mold growth. Results indicate that atmospheres of 85 percent carbon dioxide in air would be highly effective in limiting mold growth and aflatoxin production in high moisture peanuts. (MQ 2-103)

3. Development and Control of Mycotoxins in Spanish Peanuts. A test of aflatoxin production on sterile shelled peanuts indicated that all 11 varieties included in the test were effective substrates for the production of aflatoxin.

Extensive tests of the effect of temperature on aflatoxin production in peanuts have shown that in the range of 20 to 35° C. (60 to 95° F.) increasing temperature is inversely related to the time required for significant concentrations of aflatoxins to be produced and accumulated. Above 35° C. (95° F.) toxin production and accumulation declines rapidly until at 40° C. (104° F.) little or no aflatoxin is accumulated although the fungus appears to make a vigorous growth. Furthermore, a diurnal

temperature cycle of 12 hours at 20° C. (60° F.) and 12 hours at 40° C. (104° F.) decreases toxin production and accumulation to about one-tenth of that produced at a constant temperature of 30° C. (86° F.). The incubation temperature also affects the proportional accumulation of the four principal aflatoxins. Aflatoxin B tends to increase in concentration in respect to that of G as the temperature increases. (MQ 2-103)

In a Crops Research Division P.L. 480 project, Aspergillus niger was found to be the most common fungus on peanuts in Israel. The quantity of A. flavus in the kernel mycoflora was found to be relatively small but it increased during storage and during shelling. A. flavus was found in peanut soils at all locations that were investigated. Tests showed that 71.2 percent of the A. flavus isolates from peanut were toxic while 91.1 percent of the isolates from soil were toxic. The introduction of A. flavus to soil had no adverse effect on peanut plants grown therein. The fungus continued to survive in the soil after five months.

4. Development and Control of Mycotoxins in Runner Peanuts. A survey to determine the extent to which peanuts are contaminated by aflatoxin during harvest in the Albany, Georgia, area showed no significant aflatoxin contamination after four days of windrowing. Preliminary information indicated that the major part of the contamination occurred during the period between picking and drying. Many farmers store their peanuts in trailers or elsewhere for period of up to 48 hours before having them dried. Such conditions afford a favorable environment for the elaboration of aflatoxin. (MQ 2-103)

5. Quality of Peanuts in Relation to Drying. Taste panel evaluations of the three most widely grown varieties of peanuts (Spanish, Runner and Virginia) dried in three types of experimental dryers indicated that, in bin dryers, air temperatures of 125° F. when alternated with ambient air every 60 minutes may be used without causing off-flavor or flavor-differences. It was found that peanuts with high initial moisture (45 percent) have an off-flavor when dried with infrared heat by exposing for four-minute periods and alternating with ambient air cooling. Shorter exposure periods have no significant effect on flavor. With a belt dryer, it was also found that flavor differences will result when high moisture peanuts are dried by exposing to an air temperature of 130° F. for 60 minutes, alternated with 60 minute exposures of ambient air. Shorter exposure periods with lower temperatures apparently have no significant effect on flavor. No significant flavor change was found in peanuts dried on the belt dryer from an initial moisture content of 20-25 percent even at a drying air temperature of 145° F. Skin slippage tests on Spanish, Runner and Virginia peanuts showed that peanuts mechanically dried from a high initial moisture content (45 percent) have an abnormally high skin slippage. Spanish peanuts have a higher skin slippage than the other two types when

all are dried under the same conditions. Drying air temperatures of 115° F. and above cause a significantly higher skin slippage than peanuts dried with air. Drying temperature of 130° F. caused no further increase and a temperature of 145° F. increased skin slippage only slightly. (MQ 2-107)

6. Physiological and Biochemical Factors Involved in the Production of Aflatoxin by Aspergillus flavus. Preliminary investigations have dealt with the determination of the various growth conditions of Aspergillus flavus and estimation of different metabolic products, such as carbohydrates, proteins, kojic acid and alpha keboacids on a standard growth medium. The presence of enzymes of the citric acid cycle were demonstrated for the first time in Aspergillus flavus. (A7-MQ-7)

7. Natural Antioxidants in Vegetable Oil Storage. After adaptation of the falling film molecular still to its use as a deodorizer, approximately 400 samples of refined and crude cottonseed, soybean, corn and safflower oils have been deodorized to simulate methods used in commercial practice. The presence of primary and secondary oxidation products in the oils after heat treatment and before deodorization are confirmed by peroxide values after deodorization. Further laboratory tests are to be made on the deodorized oil now held frozen. (MQ 3-25)

8. Vegetable Oil Storage. The effect of metals and light upon olive, peanut and soybean oils in storage from 800 to 900 days indicated the following: None of the crude peanut and olive oils in contact with metals (copper, iron, zinc, tin stainless steel) reached a peroxide value of 100. Refined soybean and olive oils, after about 800 days, exceeded this value. (E15-AMS-12)

9. Effects of Storage Temperatures on Quality of Vegetable Salad Oils. Cottonseed and soybean salad oils in one-gallon sealed containers have been under heat treatment for periods up to 18 months. Flavor panel evaluations at the end of 6, and at the end of 12 months, show that three soybean salad oils held at temperatures of 90°, 100°, and 110° F. for periods up to 12 months have developed off-flavors significantly different from the control oils (which have been held frozen). Three cottonseed salad oils held at these same temperatures up to the end of 12 months show slight deterioration in flavor, which is not as yet significantly different from the frozen control oils. (MQ 2-106)

10. Estimating Stinkbug Damage in Soybeans. Soybeans damaged by stinkbugs show an increase variation in the moisture contents of individual seeds. Determination of the range of moisture contents in a sample of soybeans may give a means of detecting, and of estimating the extent of stinkbug damage. No compound, which could be readily determined, has been found in damaged beans which is not present in undamaged beans. (MQ 3-65)

C. Prevention of insect infestation

1. Biological and Physical Control. Intermediate-scale experiments showed that 4 inert dusts applied at 3 rates on farmers stock peanuts were not as effective as the standard malathion treatment after 9 and 12 months of storage. Under conditions of this test, the breakdown of effectiveness of the inert dusts occurred between the 6th and 9th months of storage. (MQ 1-27(Rev.))

The almond moth was the most prevalent insect in peanut shelling plants as determined by "blacklight" suction-type traps. The red flour beetle was the beetle captured in greatest numbers. Lesser numbers of 15 other common stored-product insects were captured by the traps. The treatest numbers of insects were taken during the warmer summer months after the shelling plants had closed down for the summer. (MQ 1-12)

Light trap tests in peanut warehouses showed that Indian-meal moths gave the greatest positive response to green light. Cigarette beetles and lesser grain borers responded in greater numbers to traps with ultraviolet sources. Light traps suspended horizontally in peanut warehouses captured greater numbers of adult moths than did traps suspended vertically. (MQ 1-12)

Indian-meal moth larvae from a corn mill were found infected with a crystal-forming bacterium resembling Bacillus thuringiensis. Indian-meal moth larvae from peanut warehouses were found infected with a granulosis virus, only recently found in this moth in California. This is the first known appearance in peanut warehouses. Almond moth larvae from peanut warehouses were found infected with a polyhedrosis virus, the first known report from this species. Both viruses were highly infectious in laboratory feeding studies. The polyhedrosis virus was more host specific than was the granulosis virus. (Exploratory)

All red flour beetle adults in shelled and inshell peanuts stored in hermetically sealed 1-gallon bottles at 40°, 80°, and 100° F. were dead within 4 weeks. Trogoderma glabrum and rice weevil adults were exposed 3 and 7 days and T. glabrum larvae 7 and 14 days at 40°, 60°, 80°, and 100° F. to binary and ternary mixtures of nitrogen, oxygen, and carbon dioxide. All of the insects were killed within 7 days at 80° F. when exposed to the binary mixtures containing 0.5 percent or less of oxygen or to ternary mixtures containing 2 percent or less of oxygen and 93 percent or more of carbon dioxide. The T. glabrum and rice weevil adults were also killed within 3 days when the oxygen concentration was 13.5 percent or less and the carbon dioxide concentration 47.5 percent or more. One-day-old Indian-meal moth eggs were exposed for 7 and 14 days at 80° F. to binary and ternary mixtures

of oxygen, nitrogen, and carbon dioxide. With the exception of the binary mixtures consisting of 10.5 percent of oxygen and 89.5 percent of nitrogen, two-thirds or more of the eggs were dead within 2 days after a 1-week exposure. Maximum mortality occurred in mixtures with 2.7 percent of oxygen or less. (MQ 1-12)

Trogoderma glabrum larvae were exposed 2, 4, and 7 days in wheat in towers purged with nitrogen and carbon dioxide. At 100 and 200 cc./min. nitrogen and carbon dioxide reduced the oxygen concentration to about 1 percent in 1 day. At the higher purging rate, carbon dioxide killed 98 percent of the larvae within 4 days, while nitrogen killed only 65 percent within 7 days. At 100 and 50 cc./min. carbon dioxide killed 100 and 89 percent of the larvae, respectively, within 7 days. Red flour beetle adults were exposed to nitrogen and carbon bioxide purging for 6 and 24 hours in towers containing shelled and inshell peanuts. An average of less than 2-percent mortality occurred among the insects exposed for 6 hours only. Carbon dioxide purging for 24 hours at 100 and 200 cc./min. killed an average of 47 and 81.5 percent of the insects, respectively, in the inshell peanuts. However, a mortality of only 22 and 60 percent of the insects, respectively, occurred in the shelled peanuts. Nitrogen at 200 cc./min. killed only about 7.5 percent of the insects in inshell peanuts, while about 60 percent of the insects in the shelled peanuts were dead. (MQ 1-12)

2. Improved Pesticidal Control. Diazinon and fenthion at application rates up to 20 p.p.m. were not as effective as the standard malathion treatment and were not at all effective after 6 months, in small-bin intermediate scale tests with farmers stock peanuts. After 9 months of storage the peanuts originally treated with 20 p.p.m. of diazinon contained less than 1 p.p.m. of deposit. (MQ 1-27(Rev.))

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Objective Measurements and Evaluation of Quality

Schroeder, H. W., and L. J. Ashworth, Jr. 1966. Aflatoxins: Some factors affecting production and location of toxins in Aspergillus flavus-oryzae. Journal of Stored Products Research. 1:267-271. (MQ 2-103)

Pattee, H. E., E. O. Beasley, and J. A. Singleton. 1965. Isolation and identification of volatile components from high-temperature-cured off-flavor peanuts. Journal of Food Science. 30: 338-392, No. 3. (MQ 3-88)

Velasco, James. 1965. Improved techniques in neutral oil determinations. Journal of the American Oil Chemists' Society. 42: 160, No. 2, February. (MQ 3-45)

Prevention of Insect Infestation

Press, Arthur F., Jr., and Phillip K. Harein. 1965. Mortality of adult red flour beetles, Tribolium castaneum (Herbst), and atmospheric gas concentrations in simulated peanut storages purged with carbon dioxide and nitrogen. Bul. Ent. Soc. Amer. 11(3): 178. (MQ 1-12)

Press, Arthur F., Jr., and Phillip K. Harein. 1966. Mortality of red flour beetle adults and Indian-meal moth larvae in nitrogen and carbon dioxide. Jour. Ga. Ent. Soc. 1(2): 15-17. (MQ 1-12)

PUBLICATIONS -- STATE EXPERIMENT STATIONS
and COOPERATIVE PROGRAMS

A. Objective Measurement and Evaluation of Quality

Pomeranz, Y. 1965. Evaluation of factors affecting the determination of nitrogen in soya products by the biuret and orange-G dye-binding methods. J. Food Sci. 30(2), pp. 307-311. (Kans.)

Young, Clyde T., and Holley, K. T. 1965. Comparison of peanut varieties in storage and roasting. Ga. Agr. Exp. Sta. Tech. Bul. (n.s.) 41. (Ga.)

FIELD CROPS - MARKETING FACILITIES, EQUIPMENT AND METHODS
Transportation and Facilities Research Division, ARS

Problem. Differences in varieties of individual field crops and in the environments of producing areas where they are conditioned and stored, together with advancing techniques in cultural and harvesting practices, require new or modified marketing facilities, equipment, and methods. Such changes are essential to the efficient and economical handling, conditioning, and storing of these crops and to maintaining their quality. There is a need for improved designs for facilities based on functional and structural requirements, which will expedite the movement of commodities into, within, and out of the facility. There is also a need for handling and conditioning equipment which will minimize labor and other costs and also minimize the extent of physical damage (breakage) to the grain as it is handled into, within, and out of marketing facilities. More knowledge is needed of the relative efficiency of various handling and conditioning methods so that improved or revised methods and equipment can be developed to perform necessary operations.

USDA PROGRAM

The Department has a long-term program involving engineers engaged in both applied and basic research on, as well as application of known principles to, the solution of problems of handling, storing, and conditioning field crops in marketing channels. Research on the handling, drying, aerating, storing and shelling of peanuts is conducted by the Albany, Georgia, field office at laboratory and pilot-scale facilities in Dawson, Georgia, in cooperation with the Georgia Agricultural Experiment Stations, the Market Quality Research Division, and with various industry firms; and supplemented by a research cooperative agreement with Tuskegee Institute, Tuskegee, Ala.

The Federal effort devoted to research in this area during the fiscal year 1966 totals 4.0 professional man-years to the handling, drying, aerating, storing, and shelling of peanuts.

REPORT OF PROGRESS OF USDA AND COOPERATIVE PROGRAMS

A. Shelling, Handling, Drying, Aerating, and Storing Peanuts

1. Shelling. At Albany, Ga., tests were conducted to evaluate a full-scale first-stage sheller and to determine its optimum cylinder speed. Four different commercial makes were tested by shelling Spanish-, Runner-, and Virginia-type peanuts at speeds ranging from 165 to 325 r.p.m. Results showed a significant increase in the percentage of split kernels as the cylinder speed increased. While some shellers caused significantly less kernel damage than others, this frequently was at the expense of a decreased shelling rate. Charts were prepared showing the percentage of split peanuts occurring at different cylinder speeds. Only two of the four shellers showed similar characteristic optimum speeds whether shelling Runner- or Spanish-type peanuts.

Official grade information was obtained on samples of each lot of peanuts used in the shelling tests. The percentage of hulls, meats, foreign material and damage based on the official grade was in substantial agreement with shelling results. However, the out turn of split kernels from the tests was 2.0 to 2.8 times that predicted by official grade for Runner-type, 0.5 to 1.0 times for Spanish-type, and 0.8 to 1.1 times for Virginia-type peanuts.

The study on presizing farmers stock peanuts confirms that, although the shelling performance of a conventional peanut sheller depends primarily on the size of the pod, the number of split kernels is directly related to the difference between the kernel and grate opening size. In studying the separation of farmers' stock peanuts, a slotted vibrating screen was found more efficient than a round hole screen, while the round hole screen was more efficient for separating shelled peanuts.

2. Handling. At Tuskegee, Ala., under a research cooperative agreement with Tuskegee Institute, laboratory investigations were initiated to obtain factual information on the angle of repose and coefficient of friction of farmers stock peanuts. This information will supplement the peanut research being conducted by the Albany, Ga., field office. Three types of peanuts--Spanish, Runner, and Virginia--are being grown in 1966 to assure a supply of peanuts of known history such as source, grade, variety, state of maturity, and applicable physical properties. The angle of repose for filling or piling and for emptying or funneling will be determined for the three varieties with kernel moistures in the range between 6 and 40 percent. The coefficient of friction of farmers stock peanuts on various construction materials will be determined under the same conditions as specified for the angle of repose studies.

3. Drying. The limited exposure method of drying peanuts was studied using an experimental belt dryer. Two nine-test series each using either Spanish- or Runner-type peanuts originally at 20-25 percent moisture, and an eleven-test series using Virginia-type peanuts originally at 40-45 percent moisture were conducted. The treatments varied, using drying air at either 115°, 130°, or 145° F. and exposure periods of 7½, 15, 30, and 60 minutes. Peanuts were cooled to ambient temperature after each exposure to heat. Results indicate Spanish-type peanuts dried the fastest using short periods of exposure to heat, while Runner- and Virginia-type dried slightly faster using the longest exposure. Shelling the dried peanuts produced little splitting in all three types regardless of drying temperature and exposure. However, peanuts artificially dried immediately following digging were high in skin slippage and split kernels. Off-flavor was indicated only in Virginia-type peanuts dried at 145° F. Aflatoxin contamination occurred only in high moisture Runner-type peanuts.

Three deep-bed drying methods were studied using either ambient or heated air moving in an upward direction or alternately up and down. Results showed no aflatoxin contamination or difference in flavor in any of the tests on the three types of peanuts.

Infrared drying tests were conducted with Spanish- and Virginia-type peanuts to determine the effect of high temperature, short time drying on peanut flavor, aflatoxin contamination, and milling characteristics. Spanish-type peanuts increased in temperature 63° F. and lost 3½ pounds of moisture during the longest (4 minute) exposure period. This caused 4 percent splits when the peanuts were shelled. No off-flavor or aflatoxin developed. Virginia-type peanuts increased 53° F. and lost 2.8 pounds during the longest exposure period. Here the degree of splitting was not affected by exposure times. Off-flavor tests were not conclusive. Aflatoxin was not present in any of the peanuts dried in these tests.

4. Storage. Tests were conducted to determine the percent humidity necessary to prevent moisture loss in shelled peanuts stored under refrigeration. Results showed that Runner-type peanuts originally at 7½ percent moisture content and stored at 38° F. for 100 days required aeration with 60 percent relative humidity air to prevent the peanuts from losing moisture and to maintain their quality.

PUBLICATIONS - USDA AND COOPERATIVE PROGRAMS

Shelling, Handling, Drying, Aerating, and Storing Peanuts

Davidson, J. I., and Hutchison, R. S. 1966. Some Performance Characteristics of Conventional Peanut Shellers. Peanut Journal and Nut World.

ECONOMICS OF MARKETING
Marketing Economics Division, ERS

Problem: Economic research in agricultural marketing revolves around the problems of increasing efficiency in the processing and distribution system and providing a foundation for orderly adjustments to changes inside and outside of agriculture. Marketing must be looked upon as a dynamic and changing process. The capacity to adjust to and cope with the dynamics of modern marketing is required increasingly of producers and distributors of farm products. Demands of a more knowledgeable and sophisticated consuming public are adding to the pressures for an even more rapid escalation of developments and changes within the marketing system. Changes in insitutions and redirection of public policies and programs are modifying the economic environment in which marketing firms must perform and operate. Because of rapid changes and increasing complexities associated with a dynamic marketing system, it is necessary that a continuous program of research be conducted in marketing--a program aimed at keeping producers and marketing firms abreast of the flow of events and providing information necessary to them in making proper and orderly adjustments to change.

Of increasing economic concern is the problem of how to improve and strengthen markets for farm products in face of a continuing rise in production, higher distribution costs, and competition from nonagricultural products. The problem of increasing demand for farm products to meet rising productivity has become progressively more pronounced in the last decade. Interest in the development of markets has mounted as larger and larger financial outlays become necessary for price-support operation and maintenance of reasonable levels of farm income.

USDA AND COOPERATIVE PROGRAMS

The Department has a continuing long-range program of economic research directed in two major areas: (1) Organization and performance of markets and (2) development of markets. Research on organization and performance is designed to increase the efficiency of marketing and assist producers and marketing agencies in adapting to a changing environment. Research is conducted on a wide range of functional and commodity problems that arise in moving farm products from producers to consumers. The program involves both basic and applied research and is primarily oriented to problems of national and regional scope. Field studies are often conducted jointly with State agricultural experiment stations, with processors and distributors of agricultural products, transportation agencies, and agriculturally-oriented trade groups. Producer groups and trade organizations have, with increasing frequency, made financial contributions to the Division research efforts.

Research on development of markets consists of both basic and applied research on agricultural commodities which includes the development of general principles in advertising and promotion, appraisal of public food distribution programs, and evaluation of the commercial feasibility and market potential for new and improved products.

The Federal scientist man-years devoted to oilseeds and peanuts are as follows:

Subject Matter Area	Oilseeds	Peanuts
Organization and Performance of Markets:		
Market Institutions and Market Power	1.5	1.0
Location and Interregional Competition		1.0
Development of Markets:		
Products and Services	2.0	

PROGRAM OF STATE EXPERIMENT STATIONS

Studies in States are concerned with the direction and magnitude of major changes in firm organization, economic forces, policies, and practices influencing changes in marketing grain and the relationship between economic forces and policies and the trends in market structure. Information on consolidation, integration, mergers, and their consequences, along with decision-making processes, is being sought. Information on the madnitude and future course of changes would help in expediting and directing feasible trends.

Many of the State experiment stations analyze the supply, demand, and price situation for the products of their State. USDA research is often used as a base but further research usually is needed to meet State and local needs.

PROGRESS - USDA AND COOPERATIVE PROGRAMS

A. Market Institutions and Market Power

Soybeans

Brokers and others close to futures trading activity contend that out of the three markets--soybean, soybean oil, and soybean meal--the soybean market has been the most favorable one in which to trade in recent years. On the other hand, trading has been difficult in soybean oil and meal markets. An examination of the changes in the level of concentrations of open interest for each of the commodities appears to provide a partial answer. The soybean market has shown a decline in concentration since

1958 and is the least concentrated of the three markets today. Concentration of open interest declined from 22-29 percent in the 1958 crop year to 9-15 percent in 1964. In contrast, concentration in the soybean oil market increased from 5-15 percent to 15-41 percent and for soybean meal from 16-24 percent to 20-48 percent for comparable periods.

B. Location and Interregional Competition

Peanuts

Under the peanut price support program, average price support differentials per ton are established among the four major types of peanuts. Also, within each type of peanuts, support values are assigned to each of the several kernel grades used in establishing the quality of farmers' stock peanuts. A study is underway to determine the manner in which the support price mechanism affects the commercial marketing of peanuts with respect to both the quantity and quality of each type that will be demanded by commercial outlets and the competitive relationships among the different types. Work has been initiated to develop a comprehensive interregional competition analysis of the entire peanut industry.

C. Products and Services

Special commodity studies on safflower, Kona coffee, maple sirup, dairy products, and sweetpotatoes were continued during the year. Safflower is a relatively new oilseed crop which seems to have good possibilities for expanded production in the Northern Plains and Western States. To provide a basis for effective development of this unique oil's full potential, a study is underway to obtain comprehensive information on present and potential markets.

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

A. Market Institutions and Market Power

Paul, Allen B., August 1966. "Pricing Below Cost in the Soybean Processing Industry," Journal of Farm Economics, Vol. 48, No. 3, Part II, pp. 2-22.

B. Products and Services

Corkern, Ray S., July 1966. "Crambe Abyssinica-- A Bibliography, 1964-65," ERS-299. 9 pp.

RELATED PUBLICATIONS OF STATE EXPERIMENT STATIONS

A. Market Institutions and Market Power

Hyslop, J. D., and Dahl, R. P., May 1964. The Effect of Changes in Transportation Costs on Wheat Flour Millers and Oilseed Processors. Univ. of Minn. Agr. Expt. Sta. Bul. 472.

B. Prices, Margins and Costs

Hieronymus, T. A., September 1965. "Soybean and Product Outlook," Soybean Digest, Vol. 25, No. 12.

Hieronymus, T. A., and Nakamura, H. Feb. 1965. Structure of the Soybean Processing Industry, Univ. of Ill. Agr. Expt. Sta. Bull. 706.

Hieronymus, T. A., 1965. "Forecasting Soybean and Soybean Product Prices," Guide to Commodity Price Forecasting, Commodity Research Bureau, Inc., New York, New York.

COOPERATIVE MARKETING
Farmer Cooperative Service

Problem: Farmers continue to increase their use of cooperative marketing. These cooperative operations are conducted in a marketplace where handling and processing, transportation, and distribution technology is changing rapidly, and market organization and practices are undergoing major changes. Farms themselves have changed. Farmers and their cooperatives need research results that relate to these developments and new conditions to assist them in marketing efficiently. Such research will assist farmers to strengthen their bargaining power, increase marketing efficiency, and meet effectively the quality, quantity, and service needs of today's food and fiber marketplace.

Cooperative marketing is a direct and major way for farmers to get maximum returns for their products. Farmers own and operate cooperatives specifically to increase their income from crops and livestock. Gains are not automatic, however. Cooperatives must plan and actually conduct the specific marketing program and services that will yield best returns for their members. Marketing cooperatives must know what the consumer demands, as reflected in the market. They must be able to estimate the cost of serving the market in different ways. They must understand the possibility of major economies in a well-managed joint sales program, and the methods and potentials of bargaining, and the implications of a changing market structure on operations. Management must achieve minimum costs through appropriate organization, good use of existing plant and personnel, and the correct selection and use of new equipment and methods.

USDA AND COOPERATIVE PROGRAM

The Department conducts a continuing long-range program of basic and applied research and technical assistance on problems of marketing farm products cooperatively. Studies are made on the organization, operation, and role of farmer cooperatives in marketing. While most of the research is done to help members directly improve the operation of their cooperatives, the results also often benefit other marketing firms. The work is centered in Washington, D. C. Many of the studies, however, are done in cooperation with various State experiment stations, extension services, and departments of agriculture.

Federal scientific man-years devoted to research in this area totaled 17.9. Of this number, 4.0 was devoted to improving cooperative sales distribution and pricing methods, 4.3 to potentials in cooperative marketing, 3.7 to improving operating and handling methods, and 5.9 to improving the organization, financing, and management of marketing cooperatives. Of this research 1.2 scientific man-years are applicable to oilseeds.

Research also is conducted under contract with land-grant colleges, universities, cooperatives, and private research organizations. This report includes work conducted during the present period, or release of results of work earlier completed, through contract research performed by colleges and universities in Iowa, North Carolina, and West Virginia, and by one private contractor.

PROGRAM OF STATE EXPERIMENT STATIONS

Most commodity marketing research of the agricultural experiment stations is helpful to marketing cooperatives. Some projects, however, deal specifically with cooperative marketing problems, opportunities, and impacts. The total research effort on cooperative marketing in the State experiment stations is 0.8 scientific man years.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Improving Operating and Handling Methods

1. Cotton and oilseeds. Comparisons of costs of cooperative cottonseed oil mills for 1964-65 provided guides for managers to use in improving their operations. Weaknesses and potential improvements were revealed.

Analysis of electric rates and power costs of oil mills indicated rate reductions are needed and may be obtained by some oil mills. Some mills can likely reduce power costs by operating engine generator systems. Research indicates that basket storage of cotton can be used by some gins to reduce ginning costs by $1 or more a bale. Adequate volume, repeated use of baskets during the ginning season, and efficient use of labor are needed for lowering costs with basket storage systems.

B. Improving the Organization, Financing, and Management of Marketing Cooperatives

Oilseeds. Work is underway on a general study of the organization and operating experience of cottonseed and soybean oil processing and marketing cooperatives. This study will provide guidelines for those interested in financing and managing existing cooperative oil mills or in organizing new ones.

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Improving Operating and Handling Methods

Perdue, E. J., and McVey, D. H. 1966. Oilseed Cooperatives Stressed Improvement and Efficiencies. News for Farmer Cooperatives (June).

COMMODITY SITUATION AND OUTLOOK ANALYSIS
Economic and Statistical Analysis Division, ERS

PROBLEM

Frequent accurate appraisals of the economic prospects for important agricultural commodities are necessary if farmers are to plan and carryout their production and marketing activities in an efficient and profitable way. The typical farmer cannot afford to collect and analyze all the statistical and economic information necessary for making sound production and marketing decisions. Such information is provided through a flow of current outlook information; the development of longer range projections of the economic prospects for the principal agricultural commodities; and analyses of the economic implications of existing and proposed programs affecting major farm commodities.

USDA AND COOPERATIVE PROGRAM

Fats and Oils. This work involves 1.5 professional man-years in Washington. The outlook and situation program provides a continuing appraisal of the current and prospective economic situation of fats, oils, and oilseeds. These appraisals developments of interest to the industry, and results of special studies are published 5 times a year in the Fats and Oils Situation, quarterly in the Demand and Price Situation and the National Food Situation and occasionally in monthly issues of the Farm Index and the Agricultural Situation. A comprehensive analysis of the fats and oils situation is presented at the Annual Outlook Conference, and more limited appraisals are given at meetings with industry groups. Special analyses are prepared on the probable effect of proposed programs on the acreage, price, supply, and demand for oilseed crops and for fats and oils and their products. Basic statistical series are developed, maintained, improved and published for general use in statistical and economic analysis.

PROGRAM OF STATE EXPERIMENT STATIONS

For the most part the States depend heavily on the USDA for across-the-board commodity situation and outlook research. However, the State extension staff members supplement and adapt such research information to meet the commodity situation of their States. The total direct research effort at State Experiment Stations in the situation and outlook area is small--probably no more than 2 to 3 scientific man-years. While not designed as outlook research. much of the research conducted by the experiment stations contributes to improved understanding of price-making forces, which in turn improves market situation analysis and price forecasting.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

Fats and Oils

During the past year emphasis was again focused on soybeans because of their growing importance in both the domestic and world markets. Soybeans ranked third among U.S. cash crops in 1965 and likely will improve its position in 1966. Record dollar exports of soybeans and soybean meal enabled the oilseeds and their products group to rank second only to feed grains as top dollar earner among U.S. agricultural exports in the fiscal year ending June 30, 1966.

The November 1965 Fats and Oils Situation included a special article analyzing the growth in the U.S. soybean processing industry. Processing capacity has about doubled during the past 15 years, increasing from 310 million bushels in 1951 to about 600 million in 1965. Processing mills have become larger, fewer in number, and more integrated with the mixed-feed business.

A statistical compendium tracing changes since 1909 for oilseeds, fats and oils, and their products was released in August. This handbook, which replaces a similar one issued a decade ago, was expanded to include information on foreign trade in fats and oils, price support operations, and minor oilseed crops.

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Fats and Oils

U. S. Fats and Oils Statistics, 1909-65, August 1966. USDA Statistical Bulletin No. 376, 222 pp.